Middle Eel River

Watershed Management Plan

SECTION 2

PHYSICAL DESCRIPTION OF THE WATERSHED

1/6/11

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2.1 Middle Eel River Watershed Location

The Eel River Watershed (Figure 2-1), eight digit hydrologic unit code (HUC) 05120104, in north central Indiana is a major tributary to the upper Wabash River (Gammon 1990). With a watershed area of 827.07 square miles, the Eel River is 110 miles long and originates in Allen County, Indiana. The stream flows in a southwesterly direction, passing through a total of six counties, descending approximately 2.41 feet per mile and empties into the Wabash River near Logansport in Cass County, Indiana (Gammon 1990).

The focus of this watershed management plan is the Middle Eel River Watershed (Figure 2-2) which consists of two sub-watersheds of the Eel River Watershed, ten digit hydrologic unit code (HUC) 0512010406 - Weesau Creek-Eel River (downstream) with an average slope of 3.4%, and ten digit HUC 0512010405 - Paw Paw Creek-Eel River (upstream) with an average slope of 3.3%.

The Middle Eel River Watershed is comprised of 30.13 river miles from North Manchester to Mexico, Indiana and drains a land area of 169,480 acres (265 mi^2). The Middle Eel River Watershed is within four counties as displayed in Table 2-1 and Figure 2-3.

Table 2-1. Middle Eel River Watershed – acreage per county.

County	Acres
Wabash	83,180
Miami	71,548
Kosciusko	9,586
Fulton	5,166
TOTAL	169,480

The Eel River, from South Whitley to its confluence with the Wabash River in Logansport (63 river miles), is designated as an outstanding river by the Indiana Department of Natural Resources as noted in the Indiana Register, Volume 16, Number 6, (16 IR 1677) on March 1, 1993 under the title "Natural Resources Commission, Information Bulletin #4, Outstanding Rivers List for Indiana". The outstanding rivers list is a roster of streams in the State which have particular environmental or aesthetic value.

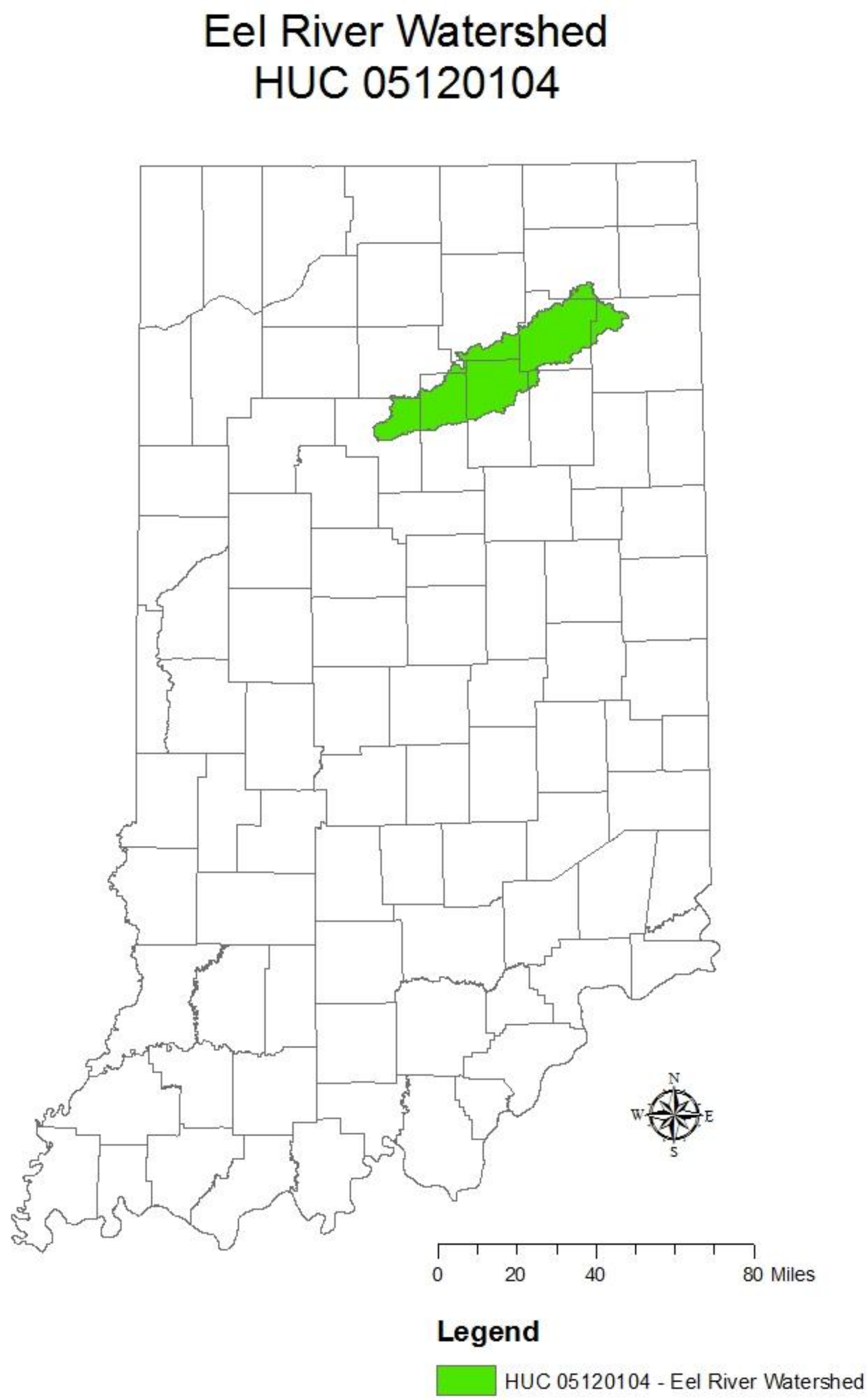

Figure 2-1. Eel River Watershed – 8 Digit HUC 05120104

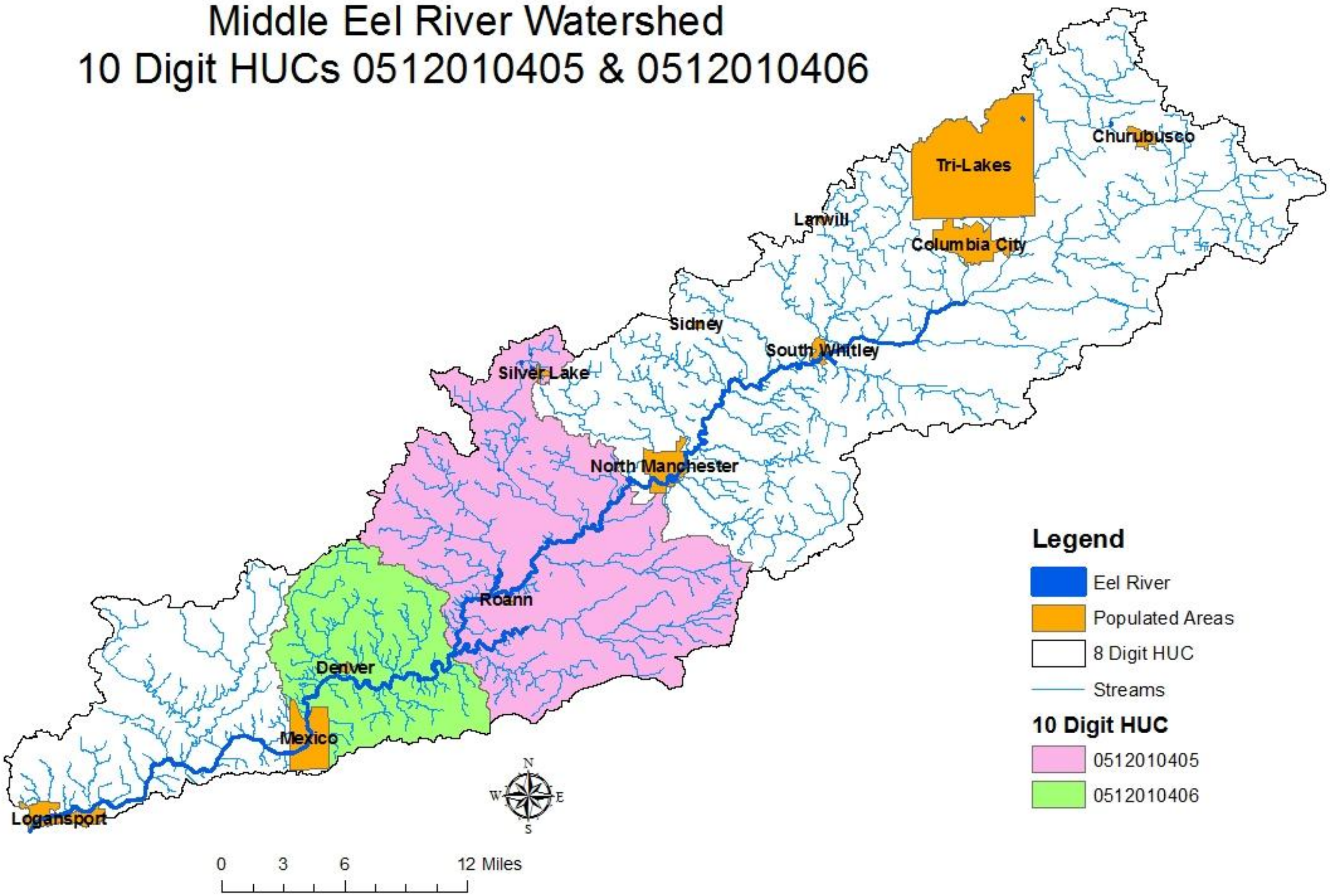

Figure 2-2. Middle Eel River Watershed - 10 Digit HUCS within Eel River 8 Digit HUC

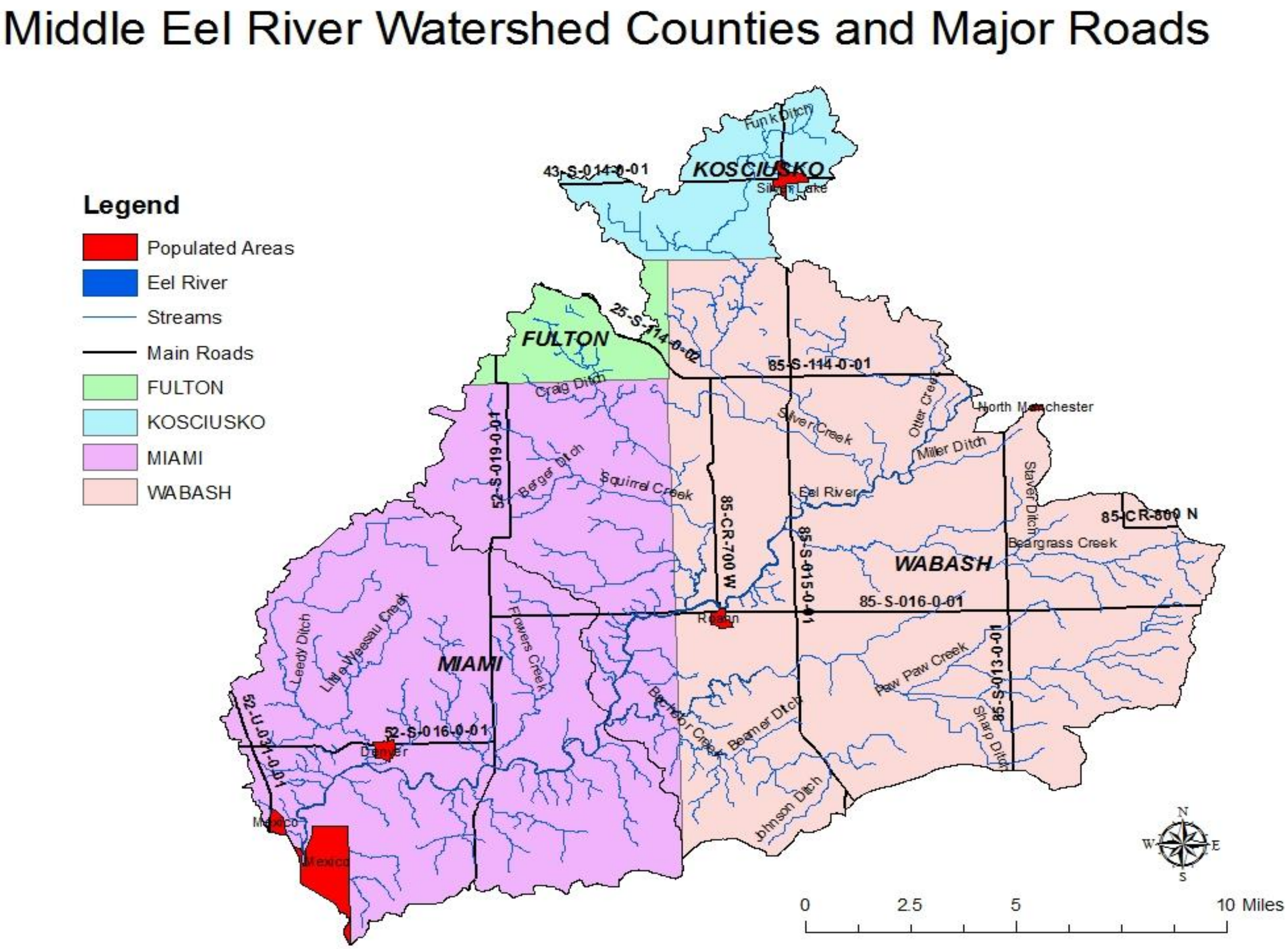

Figure 2-3. – Middle Eel River Watershed, Major Roads and Counties

2.2 – Sub-watersheds - 12 Digit Hydrologic Unit Codes

The Middle Eel River watershed contains twelve - 12 digit HUCs listed in Table 2-2 and Figure 2-4 below.

Table 2-2. Middle Eel River Watershed, 12 Digit Hydrologic Unit Codes, Geographic Names and Watershed Areas (Indiana Natural Resources Conservation Service 2005).

HUC Name	12 digit HUC	Watershed Acres
Sub-watershed 0512010406		
Flowers Creek-Eel River	051201040601	13581
Little Weesau Creek - Weesau Creek	051201040602	14853
Washonis Creek – Eel River	051201040603	20789
Sub-watershed 0512010405		
Silver Creek	051201040501	20163
Otter Creek - Eel River	051201040502	13101
Beargrass Creek	051201040503	14793
Bolley Ditch	051201040504	10586
Squirrel Creek	051201040505	15192
Sharp Ditch - Paw Paw Creek	051201040506	14161
Bachelor Creek - Paw Paw Creek	051201040507	11175
Oren Ditch - Paw Paw Creek	051201040508	9782
Town of Roann – Eel River	051201040509	11304
	TOTAL ACRES	169480

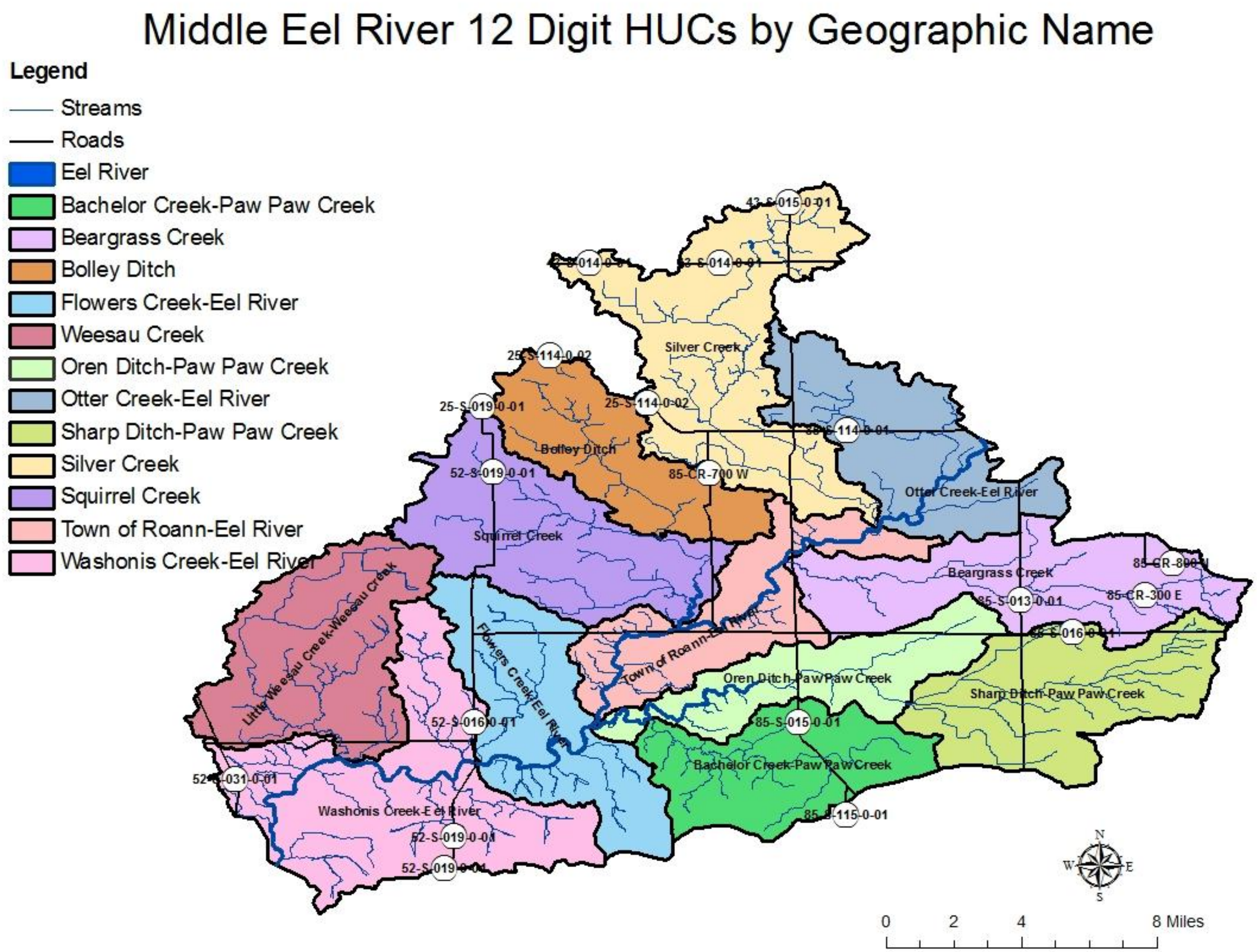

Figure 2-4 – Middle Eel River 12 Digit HUCs with Geographic Names - U.S. Geological Survey and Natural Resources Conservation Service.

2.3 Natural Regions

The Eel River is the dividing line between two natural regions, the Central Till Plain to the south of the river and the Northern Moraine and Lake Region to the north of the river, Figure 2-5.

The **Central Till Plain Natural Region** extends throughout the central portion of Indiana and is the largest natural region in the state. Nearly all the region was thickly covered and reshaped by glaciers of the Quaternary age. Glaciers covered parts of present-day Indiana at least three times during the Pleistocene Epoch (Center for Earth and Environmental Science 2003). Wisconsin and pre-Wisconsin (Illinoian and pre-Illinoian) age glaciers covered central Indiana and left deposits of till containing clay, silt, sand and gravel. Large amounts of sand and gravel outwash (glacial material which is deposited by water melting off glaciers) were deposited as both outwash plains and valley trains (Center for Earth and Environmental Science 2003). Patchy thin loess (A buff to gray windblown deposit of fine-grained, calcareous silt or clay) occurs on parts of the Wisconsin glacial deposits and swamp and lake deposits are common in poorly drained parts of the landscape. Unconsolidated deposits may be several hundred feet thick (Center for Earth and Environmental Science 2003).

Parts of glaciated Indiana are hilly and the **Northern Lakes Natural Region** typifies this kind of terrain and is noted for its spectacular scenery. Part of the topographic expression is the result of moraine (accumulated earth and stones deposited by a glacier) formation by active ice and by the overspreading of the region with ablation (the melting of snow or ice that runs off the glacier) or flow till that formed during times of glacial retreat. Large depressional areas, some of which contain lakes, form when large blocks of the melting glacial ice are buried beneath outwash sediments. With time, the buried ice blocks melt leaving behind a kettle hole or a kettle lake (Center for Earth and Environmental Science 2003).

2.4 Ecoregions

Ecoregions are areas of relative homogeneity in the quality and quantity of ecological systems and their components including soils, vegetation, climate, geology and physiography and are determined by different patterns of human stresses on the environment and different patterns in the existing attainable quality of environmental resources (EPA Ecoregions of the United States 1999).

The approach used to compile ecoregion maps is based on the premise that ecological regions can be identified by analyzing the patterns and composition of biotic (living) and abiotic (non-living) phenomena that affect or reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology (EPA Ecoregions of the United States 1999).

The relative importance of each factor varies from one ecological region to another, regardless of the hierarchical level. Because of possible confusion with other meanings of terms for different levels of ecological regions, a Roman numeral classification scheme has been adopted for this effort. Level I is the coarsest level, dividing North America into 15 ecological regions. At Level II, the continent is subdivided into 52 classes, and at Level III the continental United States contains 99 ecoregions. Level IV ecological regions are further subdivisions of level III units (EPA Ecoregions of the United States 1999).

The Eel River serves as a dividing line between two Level III Ecoregions as defined by the Environmental Protection Agency (EPA) (Figure 2-6). The watershed north of the Eel River falls within the Level III Ecoregion of The Southern Michigan/Indiana Drift Plains, while the watershed south of the Eel River falls within The Eastern Corn Belt Plains Region.

The eastern portion of the watershed north of the river is located in The Lake Country, Ecoregion Level IV. The Lake Country, is a hummocky and pitted morainal area characterized by many pothole lakes, ponds, marshes, bogs, and clear streams. The well drained end moraines and kames (a hill of sorted and layered gravel and sand, deposited in openings in stagnating or retreating glaciers) once supported oak-hickory forests whereas wetter areas had been beech forests or northern swamp forests. The very poorly drained kettles had tamarack swamp, cattail-bulrush marshes, or sphagnum bogs (Griffith & Omernik 2008).

The western portion of the watershed north of the river is located in The Middle Tippecanoe Plains, Ecoregion Level IV. The Middle Tippecanoe Plains is level to rolling and covered by ground moraine, dunes, end moraines, and lacustrine deposits (material deposited by or settled out of lake waters and exposed by the lowering of water levels or the elevation of land) (Griffith & Omernik 2008).

The entire watershed south of the river is located in The Clayey, High Lime Till Plains, Ecoregion Level IV. The Clayey, High Lime Till Plains is a transitional area with soils that are less productive and more artificially drained than the southern portion of this ecoregion, with fewer swampy areas than the northeastern portion of this ecoregion. Corn, soybean, wheat, and livestock farming are dominant and have replaced the original beech forests and scattered elm-ash swamp forests (Griffith & Omernik 2008).

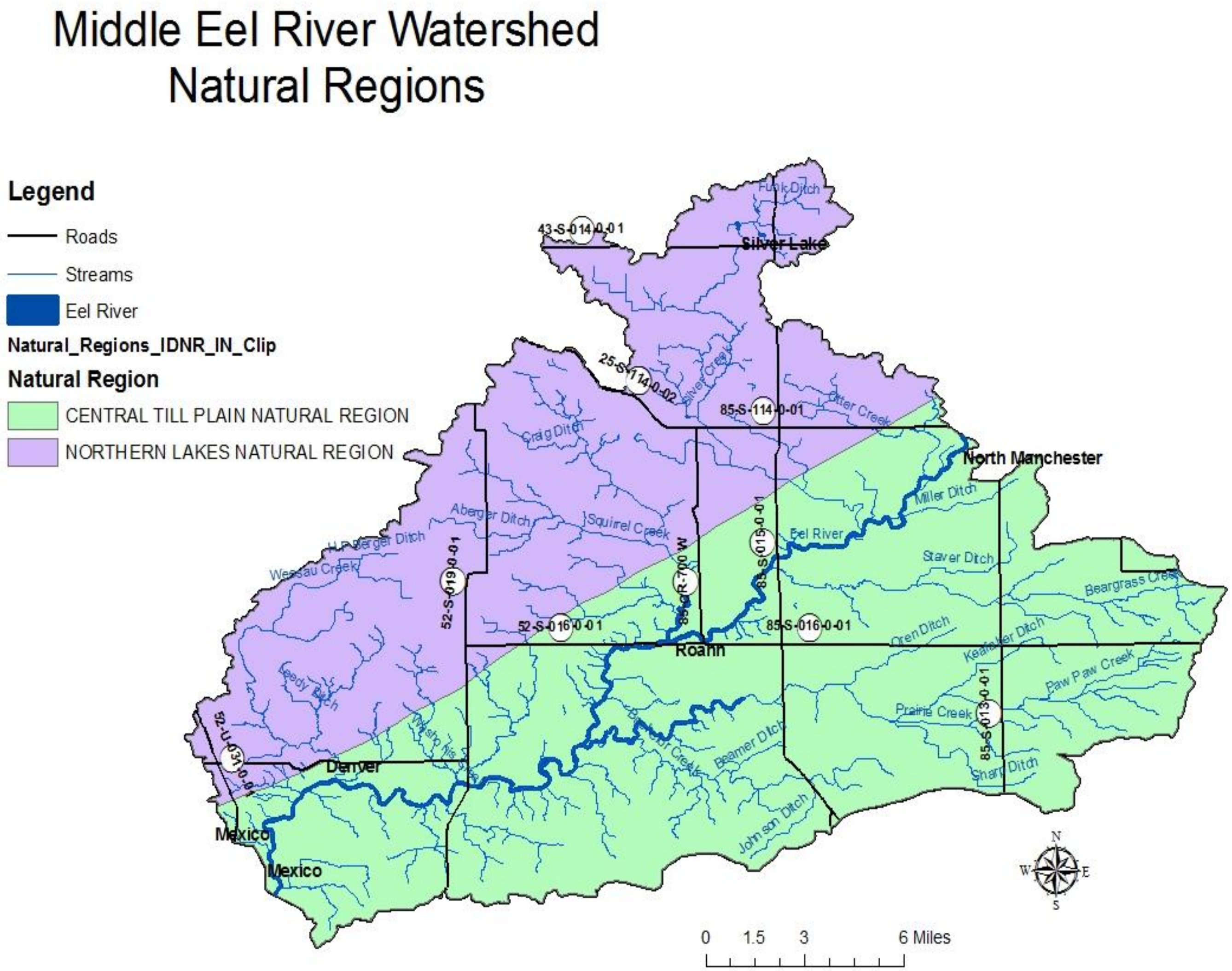

Figure 2-5. Natural Regions of Indiana - Indiana Geological Survey 1984.

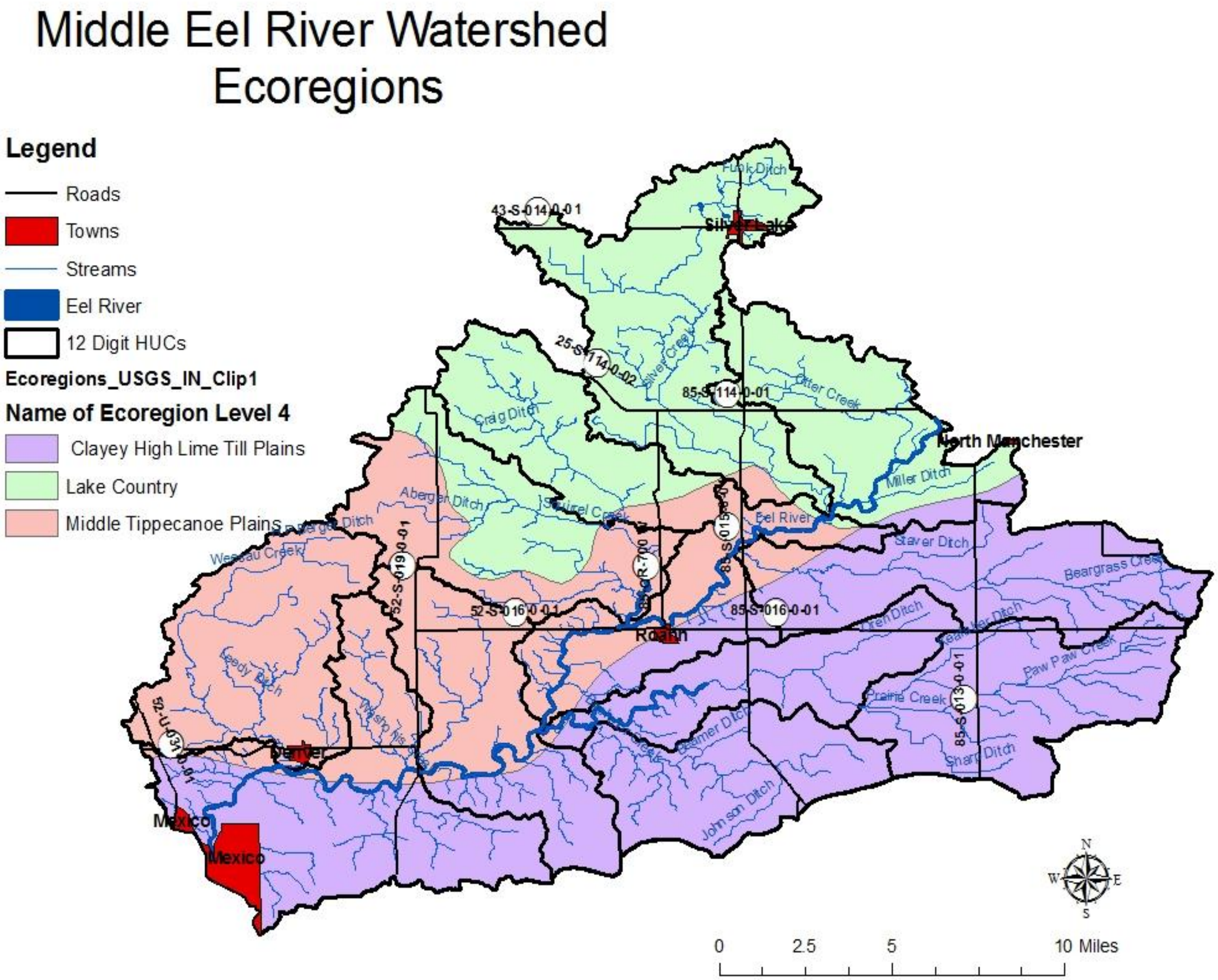

Figure 2-6. Middle Eel River Watershed, Ecoregions - Indiana Geological Survey 1984.

2.5 Soils

2.5.1 Hydrologic Soil Groups

Hydrologic group is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonally high water table, and saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently.

Hydrologic groups are used in equations that estimate runoff from rainfall. These estimates are needed for solving hydrologic problems that arise in planning watershed-protection and flood-prevention projects, for planning or designing structures for the use, control, and disposal of water. They pertain to the minimum steady ponded infiltration under conditions of a bare wet surface.

Soils are classified by the Natural Resource Conservation Service (NRCS) into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soil Groups are A, B, C and D. Where A soils generally have the smallest runoff potential and D soils the greatest (USDA TR-55).

Group A is sand, loamy sand or sandy loam types of soil. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Hydrologic soils in the Middle Eel River Watershed consists of 49.3% Group C, and 46% Group B, with very small percentages of Group D (2.2%) and Group A (2.6%). Hydrologic Soil and their percent of the watershed are listed in Table 2-3.

Table 2-3. Middle Eel River Watershed hydrologic soils by subwatershed including number of acres and percentage of watershed. (Choi, Engel & Theller, 2005)

Hydrologic Soil Group	**Group A Lowest Potential Runoff**	**Group B**	**Group C**	**Group D Highest Potential Runoff**
HUC 0512010405				
Acreage	1,389.4	17,560.9	29,397.4	365.9
% of Watershed	2.8%	36.0%	60.3%	0.7%
HUC 0512010406				
Acreage	2,997.6	59,989.3	53,752.3	3,276.8
% of Watershed	2.5%	50.0%	44.8%	2.7%
Watershed Totals				
Acreage	4,387.0	77,550.2	83,149.7	3,642.7
% of Watershed	2.6%	46.0%	49.3%	2.2%

2.5.2 Soil Associations

A soil association is a geographic area consisting of landscapes on which soils are formed. A soil association consists of one or more major soils series (soils that are very similar) and at least one minor soil series and is named for the major soil series in the geographic area (Figure 2-7). Soil associations provide a broad perspective of the soils and landscapes in the watershed, and provide a basis for comparing the potential of large areas of the watershed for general kinds of land use.

Soil Associations north of the Eel River consist primarily of Miami-Wawasee-Crosier, Blount-Glynwood-Morley, Oshtemo-Kalamazoo-Houghton with very small sections of Spinks-Houghton-Boyer and Houghton-Adrian-Carlisle Associations (Figure 2-7).

Soil Associations south of the Eel River consist of: Oshtemo-Kalamazoo-Houghton, Blount-Glynwood-Morley, Blount-Pewamo-Glynwood, Crosier-Brookston-Barry, Rensselaer-Darroch-Whitaker and Fincastle-Brookston-Miamian (Figure 2-7).

Soil series definitions (Soil Survey of Wabash County 1979):

The Blount series consists of very deep soils that are moderately deep or deep to dense till. They are somewhat poorly drained, slowly permeable soils. They formed in till. These soils are on till plains and have slopes ranging from 0 to 6 percent. Almost all areas of Blount soils are cultivated. Corn, soybeans, small grain, and meadow are the principal crops. Native vegetation is hardwood forest.

The Crosier series consists of very deep, somewhat poorly drained soils formed in till on till plains and moraines. They are moderately deep to dense till. Slope ranges from 0 to 4 percent. Soils are used to grow corn, soybeans, and small grain (wheat and oats). Some areas are used for hay and pasture. A few areas are in woods. Native vegetation is deciduous forest.

The Fincastle series consists of very deep, somewhat poorly drained soils that are deep to dense till. The Fincastle soils formed in loess or other silty material and in the underlying loamy till. They are on till plains. Slope ranges from 0 to 6 percent. These soils are mostly cultivated. Corn, soybeans, wheat, and clover-grass mixtures are the principal crops. Native vegetation is hardwood forest.

The Houghton series consists of very deep, very poorly drained soils formed in herbaceous organic deposits more than 51 inches thick in depressions on lake plains, outwash plains, ground and end moraines and on floodplains. These soils have moderately slow to moderately rapid permeability. Slope ranges from 0 to 2 percent. A considerable area of these soils is used for cropland or pasture. Common crops are onions, lettuce, potatoes, celery, radishes, carrots, mint, and some corn. Native vegetation was primarily of marsh grasses, sedges, reeds, buttonbrush, and cattails. Some water-tolerant trees were near the margin of the bog.

The Miami series consists of very deep, moderately well drained soils that are moderately deep to dense till. The Miami soils formed in as much as 46 cm (18 inches) of loess or silty material and in the underlying loamy till. They are on till plains. Slope ranges from 0 to 60 percent. Most areas are used to grow corn, soybeans, small grain, and hay. Much of the more sloping part is in permanent pasture or forest. Native vegetation is deciduous forest.

The Oshtemo series consists of very deep, well drained soils formed in stratified loamy and sandy deposits on outwash plains, valley trains, moraines, and beach ridges. Permeability is moderately rapid in the upper loamy materials and very rapid in the lower sandy materials. Slope ranges from 0 to 55 percent. Most areas are cultivated. Principal crops are small grains, soybeans, corn, and hay. The remainder is in forest or permanent pasture. Native vegetation is hardwood forest of oak, hickory, and sugar maple.

The Rensselaer series consists of very deep, poorly drained or very poorly drained soils formed in loamy sediments on till plains, stream terraces, outwash terraces, outwash plains, glacial drainage channels, and lake plains. Permeability is moderate. Slope ranges from 0 to 2 percent. Soils are used to grow corn, soybeans, and small grain. Native vegetation is swamp grasses and deciduous hardwood forest.

The Spinks series consists of very deep, well drained soils formed in sandy eolian or outwash material. They are on dunes, moraines, till plains, outwash plains, beach ridges, and lake plains. Permeability is moderately rapid. Slope ranges from 0 to 70 percent. Spinks soils are used mostly for hay production or pasture. Some areas are cropped to corn, wheat, oats, and soybeans. A small part is in orchards. Steeper areas are in forest or permanent pasture. The native vegetation is hardwoods, dominantly of oak and hickory.

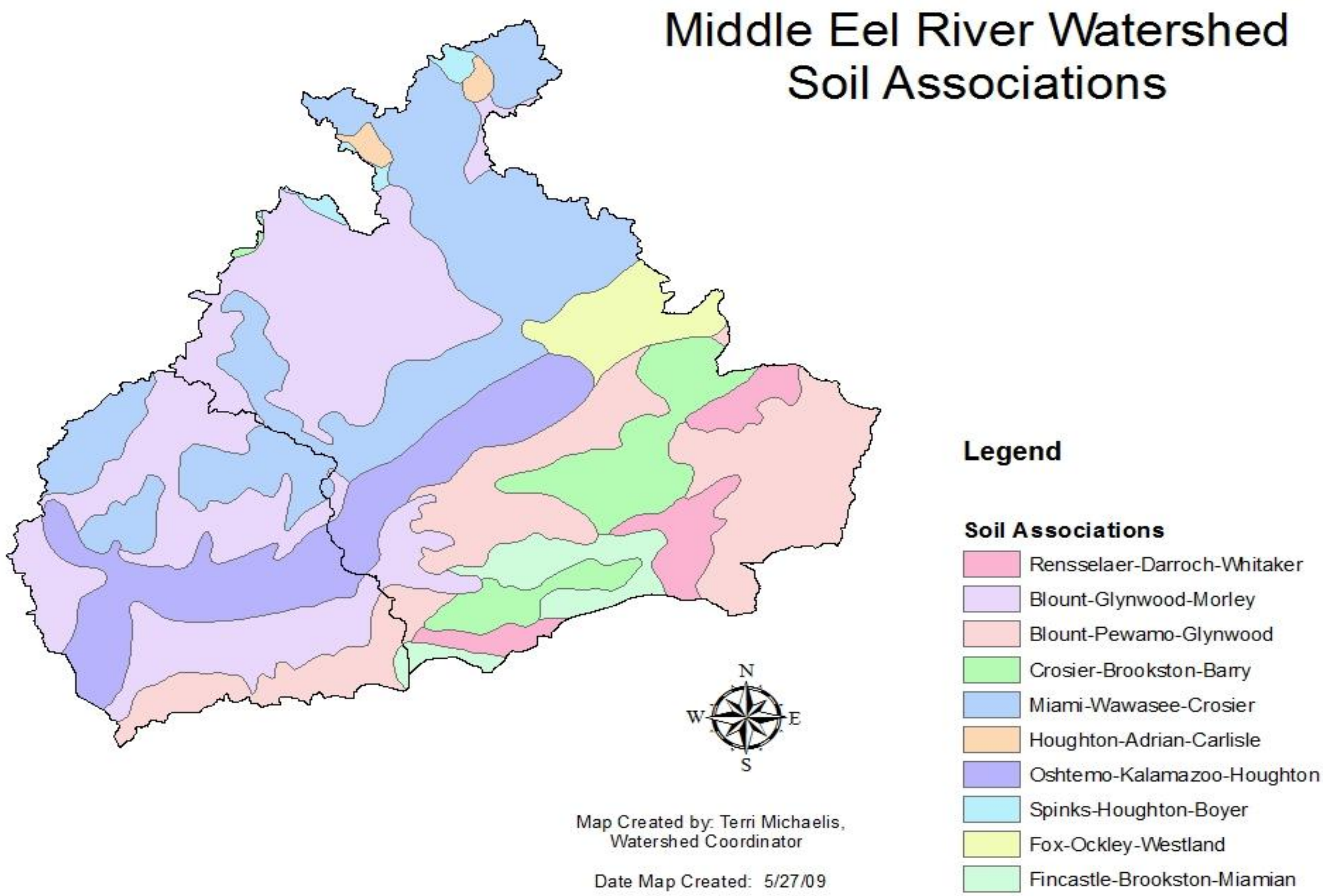

Figure 2-7. Middle Eel River Watershed Soil Associations - Indiana Geological Survey 1994.

2.5.3 Highly Erodible Land

Highly erodible soils in the Watershed were determined using the Indiana NRCS Highly Erodible Land (HEL) list uses soil type to determine HEL category. Highly erodible lands are more vulnerable to erosion which may result in an increase of total suspended solids (TSS) in rivers, creek and ditches, negatively impacting the biological community. In addition, phosphorus binds with soil particles, and as soil erodes it carries phosphorus with it and deposits it in streams, ditches and rivers. This can cause excess total phosphorus in the water, resulting in excessive algal growth and low dissolved oxygen. A map of HEL within the Middle Eel River Watershed is shown in Figure. 2-8.

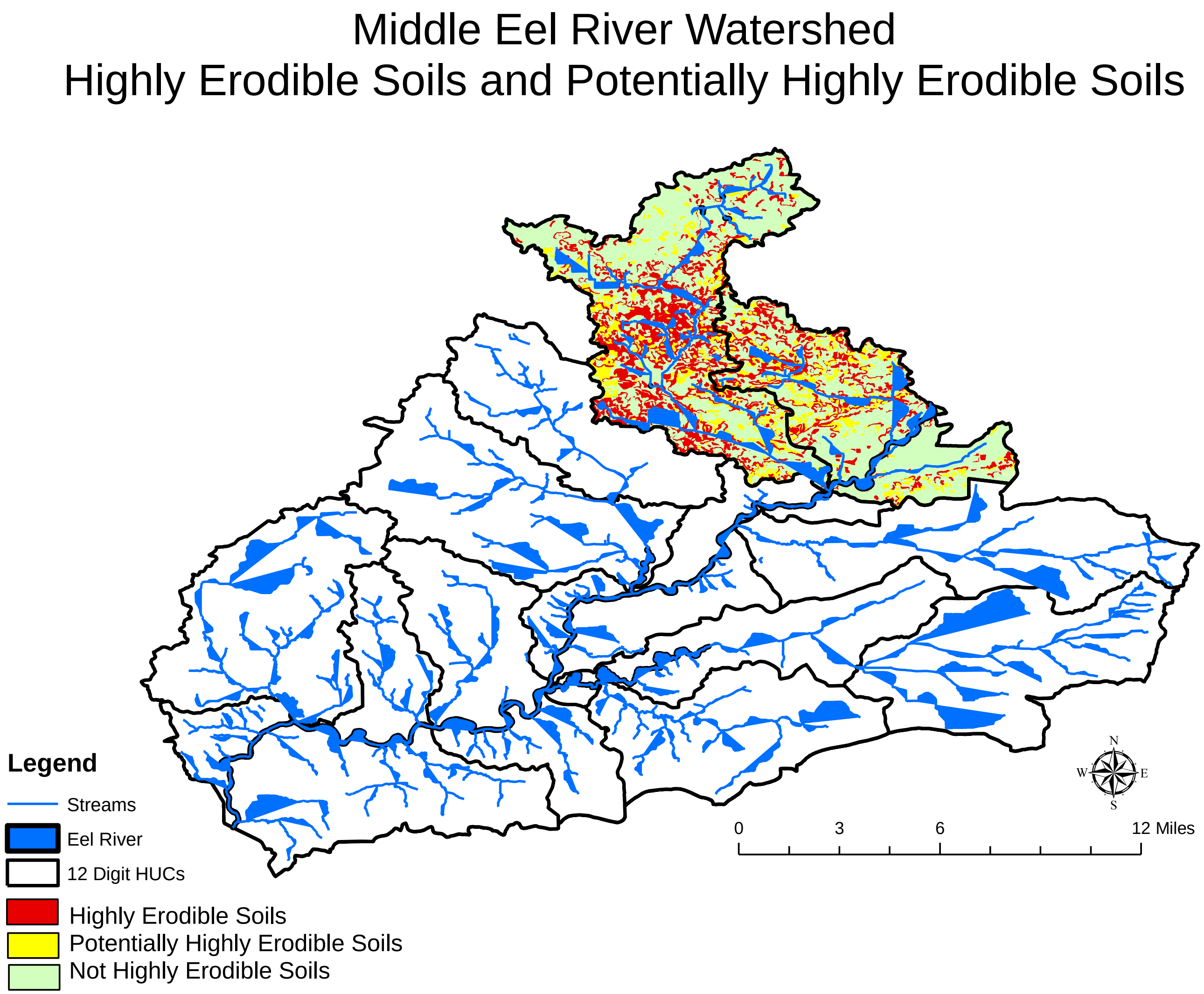

Figure 2-8. Middle Eel River Watershed Highly Erodible Land (HEL)

2.6 Aquifers

2.6.1 Bedrock Aquifers

The occurrence of bedrock aquifers depends on the original composition of the rocks and subsequent changes which influence the hydraulic properties. Post-depositional processes which promote jointing, fracturing, and solution activity of exposed bedrock generally increase the hydraulic conductivity (permeability) of the upper portion of bedrock aquifer systems. Because permeability in many places is greatest near the bedrock surface, bedrock units within the upper 100 feet are commonly the most productive aquifers.

The bedrock aquifer system for the Middle Eel River Watershed is the Silurian (425 million to 405 million years ago) and Devonian (405 million to 345 million years ago) Carbonates, Figure 2-9. Rock types exposed at the bedrock surface include moderately productive to prolific limestones and dolomites with varying amounts of interbedded shale. Most of the bedrock aquifers in the watershed are under confined conditions, meaning the water level in most wells completed in bedrock rises above the top of the water-bearing zone.

The yield of a bedrock aquifer depends on its hydraulic characteristics and the nature of the overlying deposits. Shale and clay act as aquitards, restricting recharge to underlying bedrock aquifers. However, fracturing and/or jointing may occur in aquitards, which can increase recharge to the underlying aquifers. Hydraulic properties of the bedrock aquifers are extremely variable.

The susceptibility of bedrock aquifer systems to surface contamination is largely dependent on the type and thickness of the overlying sediments. However, because bedrock aquifer systems may have complex fracturing systems, once a contaminant has been introduced into a bedrock aquifer system, it will be difficult to track and remediate.

The Silurian and Devonian Carbonate Aquifer System includes carbonate rock units (limestone and dolomite) with some interbedded shale units. In Miami County the system consists of Pleasant Mills formation and Wabash formation of Silurian age, and the Muscattauck group of Devonian age. The total thickness of the Silurian and Devonian Carbonates Aquifer System in Miami County ranges from about 100 feet to 500 feet. In Wabash County the system outcrops/sub-crops throughout nearly all the county. This aquifer system consists primarily of Silurian age carbonates and middle Devonian age carbonates of the Muscatatuck Group. Total thickness of this aquifer in Wabash County ranges from 0 to about 500 feet.

Wells penetrating the Silurian and Devonian Carbonates Aquifer in Miami County have reported depths ranging from 35 to 500 feet, but are commonly 80 to 170 feet deep. The amount of rock penetrated in this system in Miami County typically ranges from 35 to 120 feet. Wells in Wabash County penetrating this system have reported depths of 32 to 514 feet, but are typically 100 to 200 feet deep. The amount of rock penetrated in this system in Wabash County typically ranges from 30 to 90 feet.

The Silurian and Devonian Carbonate Aquifer System is generally not very susceptible to surface contamination because thick clay deposits overlay the system. However, in areas where overlying clays are thin or absent, the system is at moderate to high risk to contamination (Indiana Department of Natural Resources – Division of Water 2007).

2.6.2 Unconsolidated Aquifers

Unconsolidated aquifers (Figure 2-10) are the most widely used aquifers in Indiana. Types of unconsolidated aquifers include surficial, buried, and discontinuous layers of sand and gravel. Most of the surficial sand and gravel is located in large outwash plains in northern Indiana and along the major rivers in the southern two-thirds of the State. Buried sand and gravel aquifers underlie much of the northern two-thirds of Indiana, where they are typically interbedded with till deposits and can be 10 to 400 ft deep. Discontinuous sand and gravel deposits are present as isolated lenses, primarily in glaciated areas.

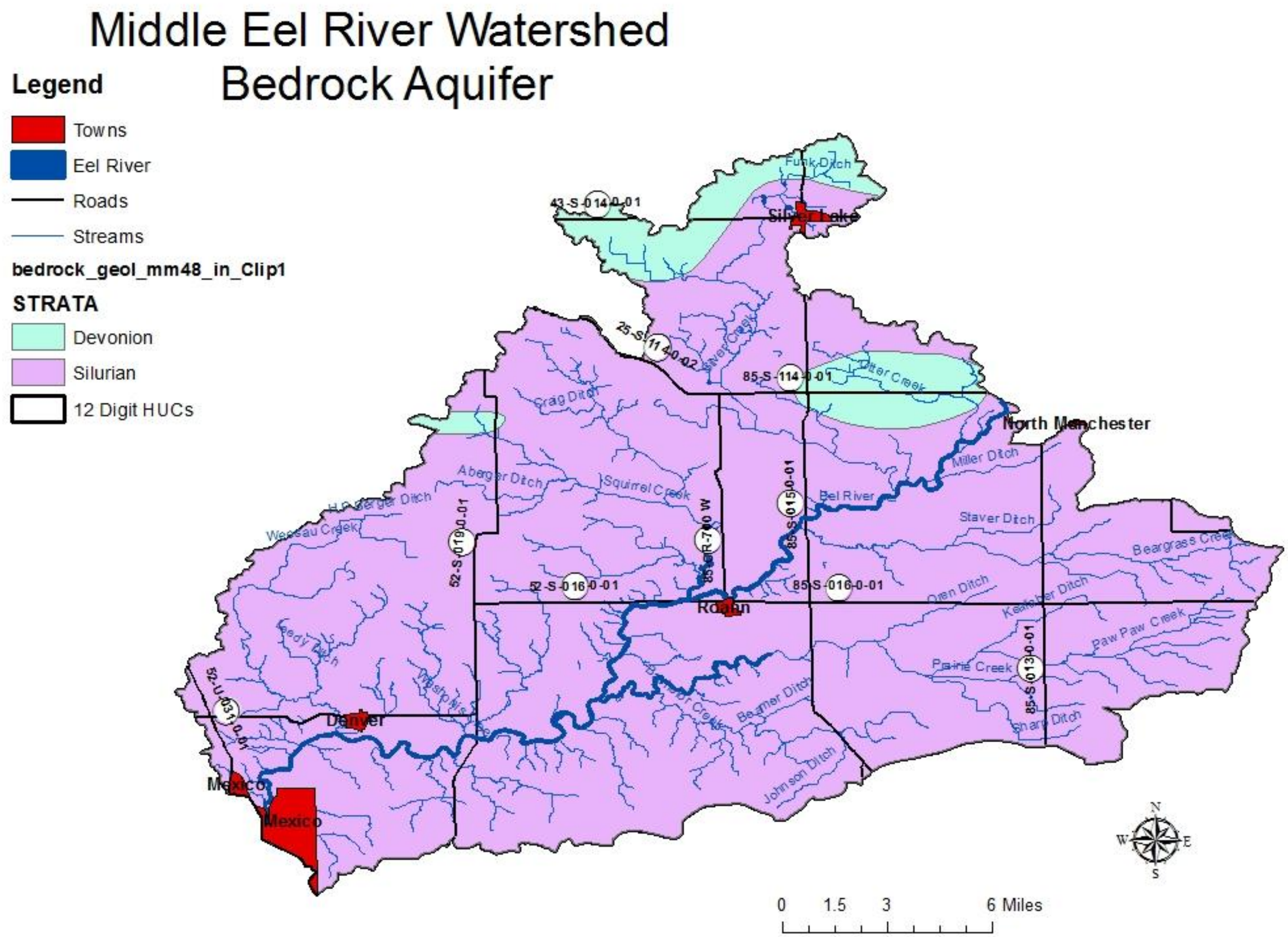

Figure 2-9. Middle Eel River Bedrock Aquifer (Indiana Geological Society 1994)

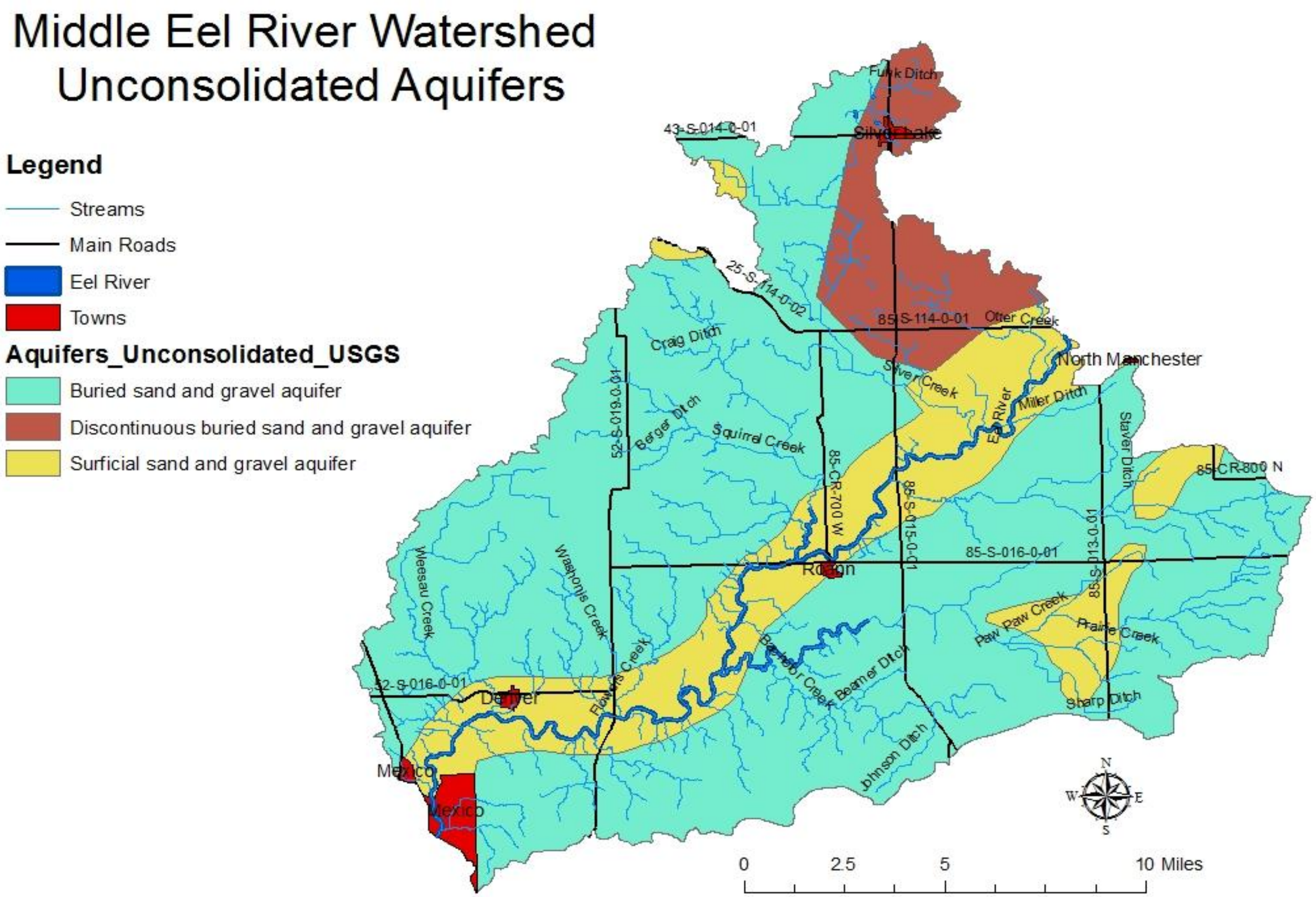

Figure 2-10. Middle Eel River Watershed Unconsolidated Aquifers - Indiana Geological Survey 1994.

2.7 Climate

Indiana's climate is classified as temperate continental and humid. Continental climates have a pronounced difference in average seasonal temperatures between summer and winter. Humid climates are those where the normal annual precipitation exceeds annual evapotranspiration. In north central Indiana the wettest seasonal period is late spring and more than half (54%) of the annual precipitation occurs during the five-six month frost free growing season. The average annual temperature for north central Indiana is 50-52°F and annual precipitation is 36-38" (Center for Earth and Environmental Science, 2003).

2.8 Land Use

Prior to European settlement of Indiana in the 1800s, the landscape was one large natural area that contained 36,291 square miles of about 20 million acres of forestland, 2 million acres of prairie, 1.5 million acres of water and wetlands, plus glades, barrens and savanna totaling perhaps another million acres (Jackson, 1997). Over the recent past, land use in the Middle Eel River Watershed has seen a dramatic transition from natural area to intense agricultural use.

Current land use in the Middle Eel River Watershed is predominantly agricultural (89%), with only small acreage of residential and forested areas. Figure 2-11 shows the land use in the Middle Eel River Watershed. Figures 2-12 through 2-29 show land use within each of the 12 digit HUCs. Figure 2-30 shows land use as a percent of total area within each subwatershed, broken down into six categories: Cultivated Crops (corn, soybeans, winter wheat, hay and alfalfa), Pasture/Range/Grasslands, Forested, Urban, Wetlands and Other (other small acreage crops, fallow cropland, clouds, and open water). As can be seen in Figure 2-30, the predominant land use within the Middle Eel River Watershed is Cultivated Crops.

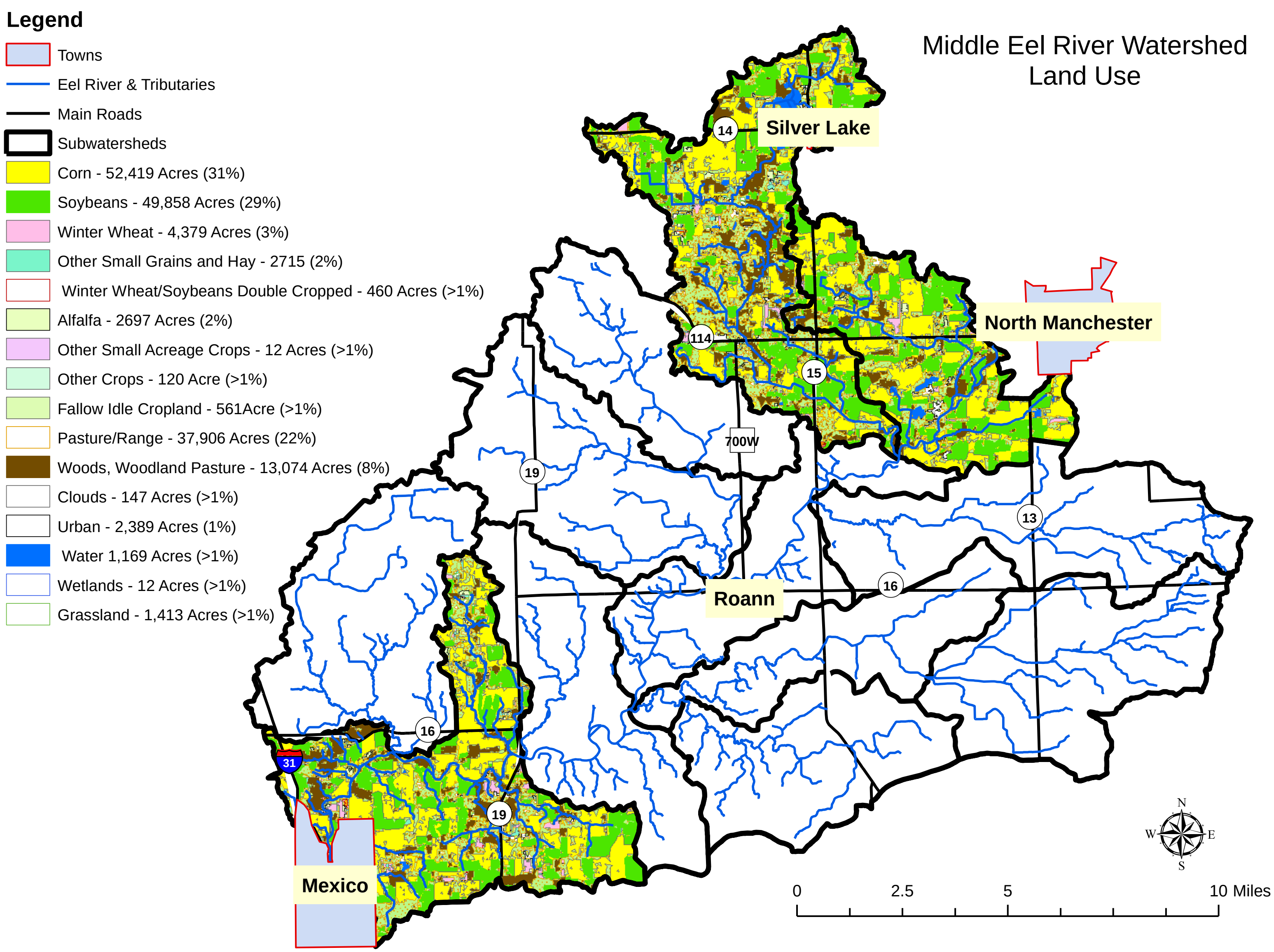

Figure 2-11. Middle Eel River Watershed Land Use

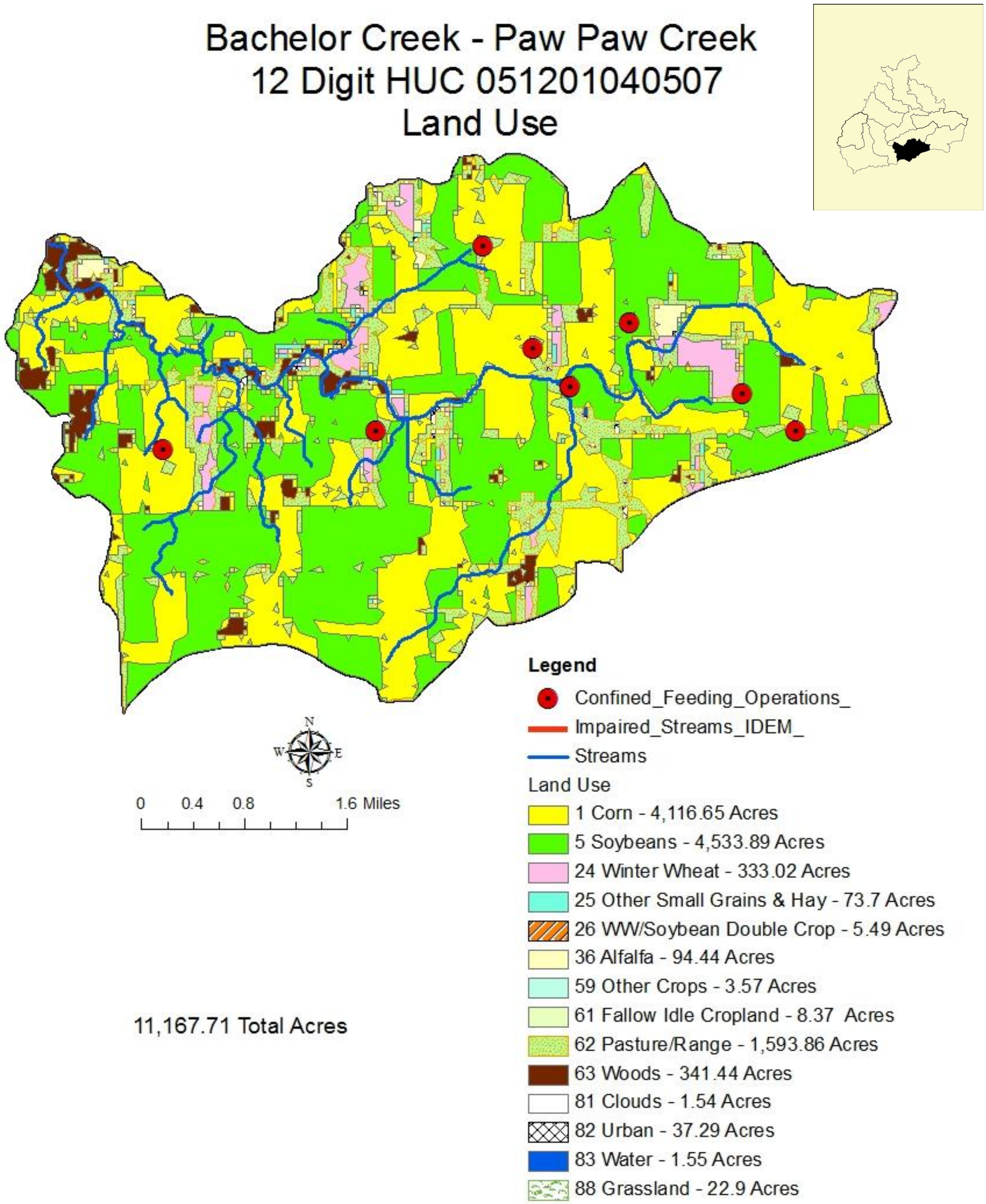

Figure 2-12. Land use in Bachelor Creek Subwatershed.

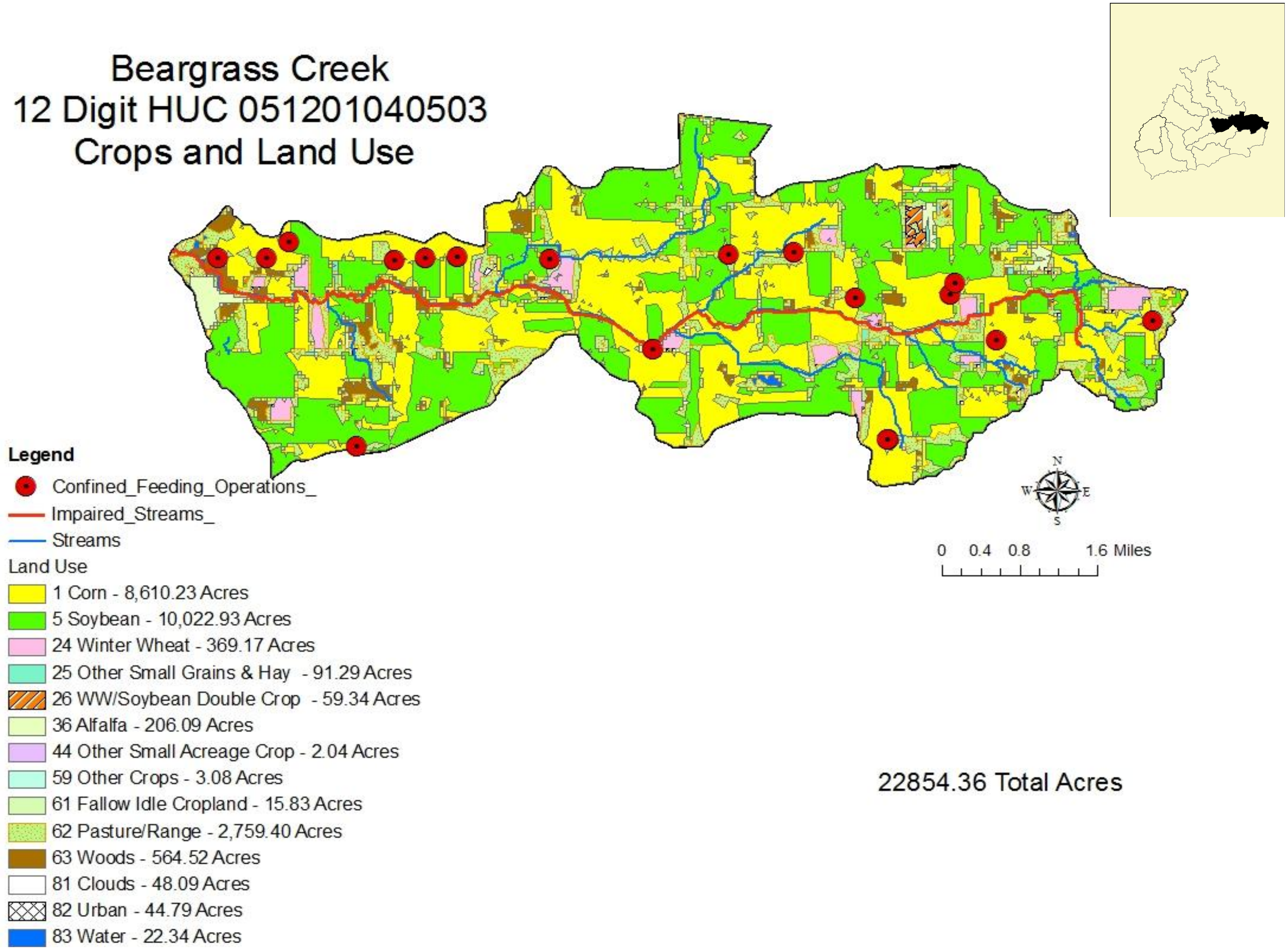

Figure 2-13. Land Use in Beargrass Creek Subwatershed.

Figure 2-14. Beargrass Creek, low stream flow with heavy algal mat growth suggesting high nutrient load. This condition is typical (9-10 times) during summer months when low flow conditions exist throughout the Middle Eel River Watershed. Photograph by Craig Colvin 2009.

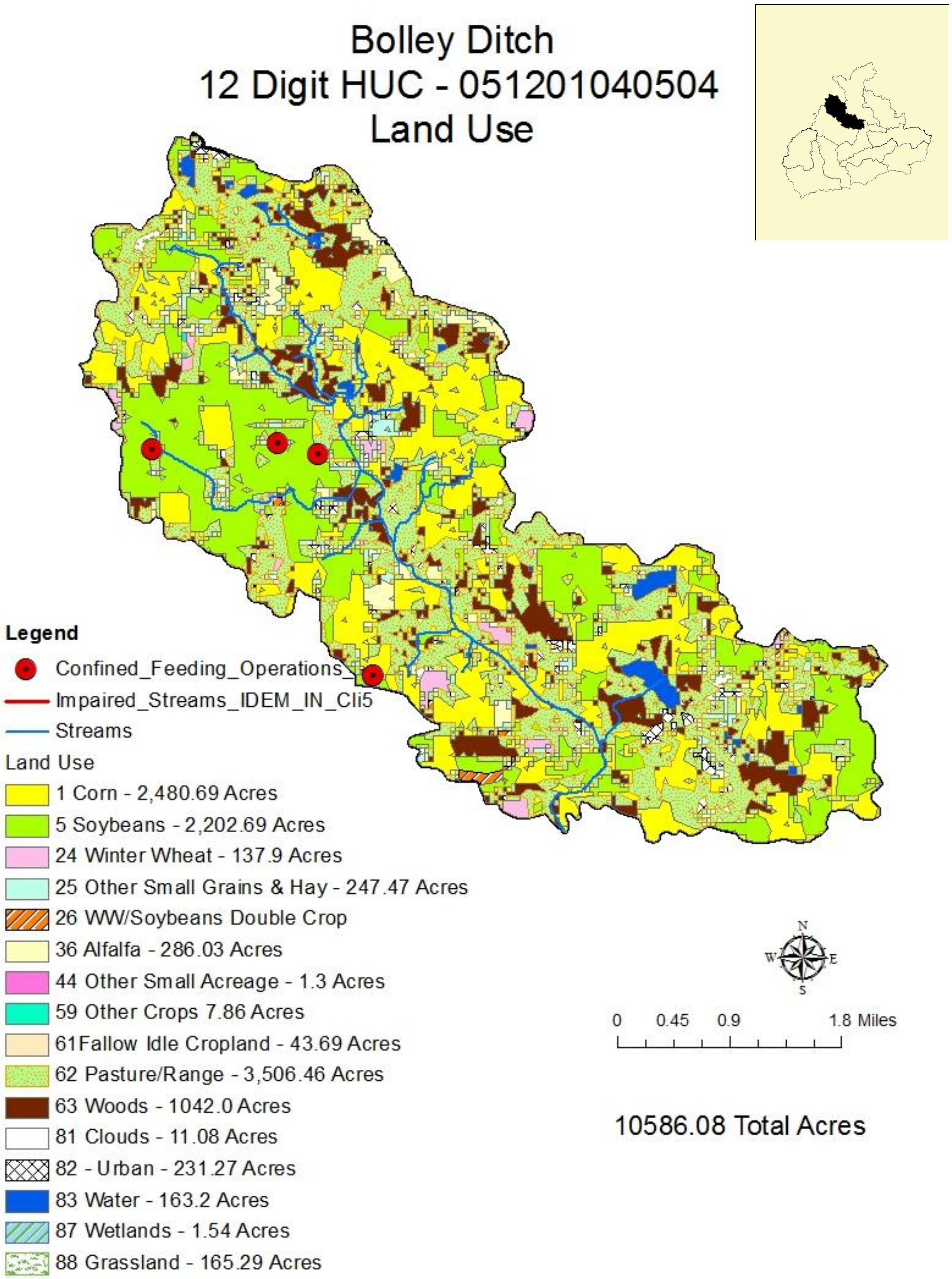
Bolley Ditch
12 Digit HUC - 051201040504
Land Use
Legend
Confined_Feeding_Operations_
Impaired_Streams_IDEM_IN_Cli5
Streams
Land Use
1 Corn - 2,480.69 Acres
5 Soybeans - 2,202.69 Acres
24 Winter Wheat - 137.9 Acres
25 Other Small Grains & Hay - 247.47 Acres
26 WW/Soybeans Double Crop
36 Alfalfa - 286.03 Acres
44 Other Small Acreage - 1.3 Acres
59 Other Crops 7.86 Acres
61Fallow Idle Cropland - 43.69 Acres
62 Pasture/Range - 3,506.46 Acres
63 Woods - 1042.0 Acres
81 Clouds - 11.08 Acres
82 - Urban - 231.27 Acres
83 Water - 163.2 Acres
87 Wetlands - 1.54 Acres
88 Grassland - 165.29 Acres
N
W
E
S
0 0.45 0.9 1.8 Miles
10586.08 Total Acres

Figure 2-15. Land Use in Bolley Ditch Subwatershed.

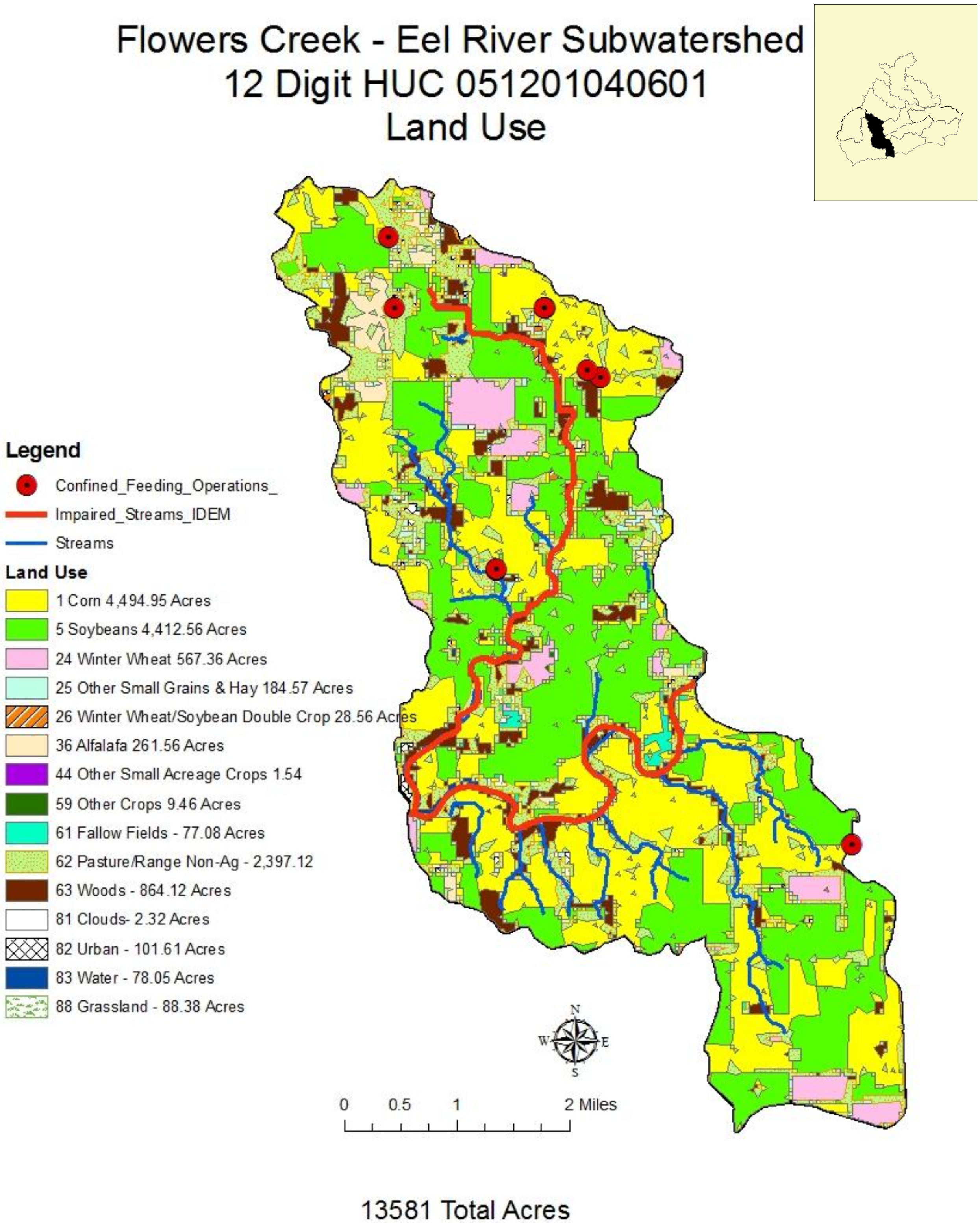

Figure 2-16. Land Use in Flowers Creek – Eel River Subwatershed.

Figure 2-17. Wilson Rhodes Ditch, part of Flowers Creek watershed. Subsurface tile drainage is typical throughout the Middle Eel River Watershed. Photo by Craig Colvin 2009.

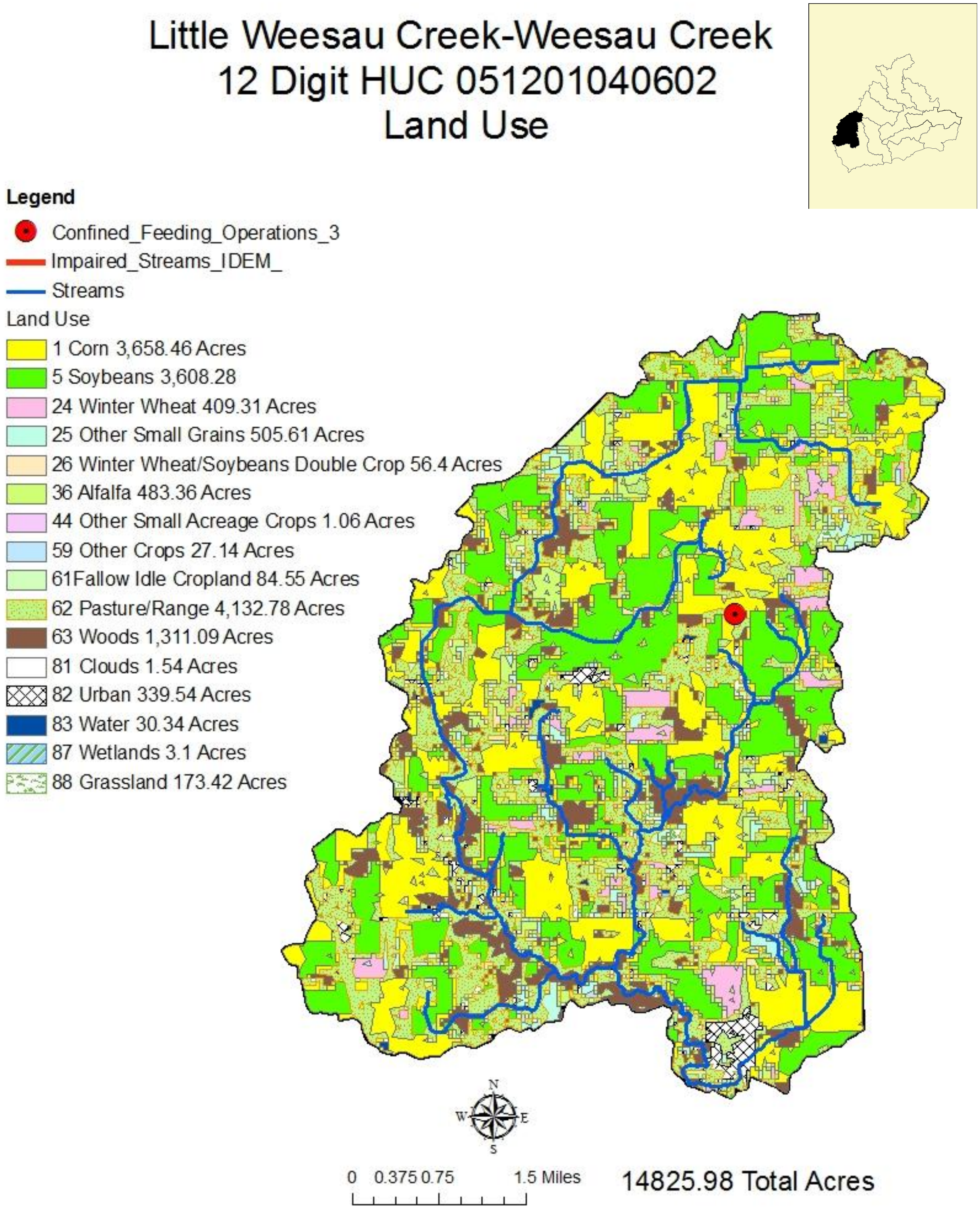

Figure 2-18. Land Use in Little Weesau-Weesau Creek Subwatershed.

Figure 2-19. In spring and fall spreading manure is typical throughout the Middle Eel River Watershed. Manure has been seen being spread on frozen fields 3 times during 2010.

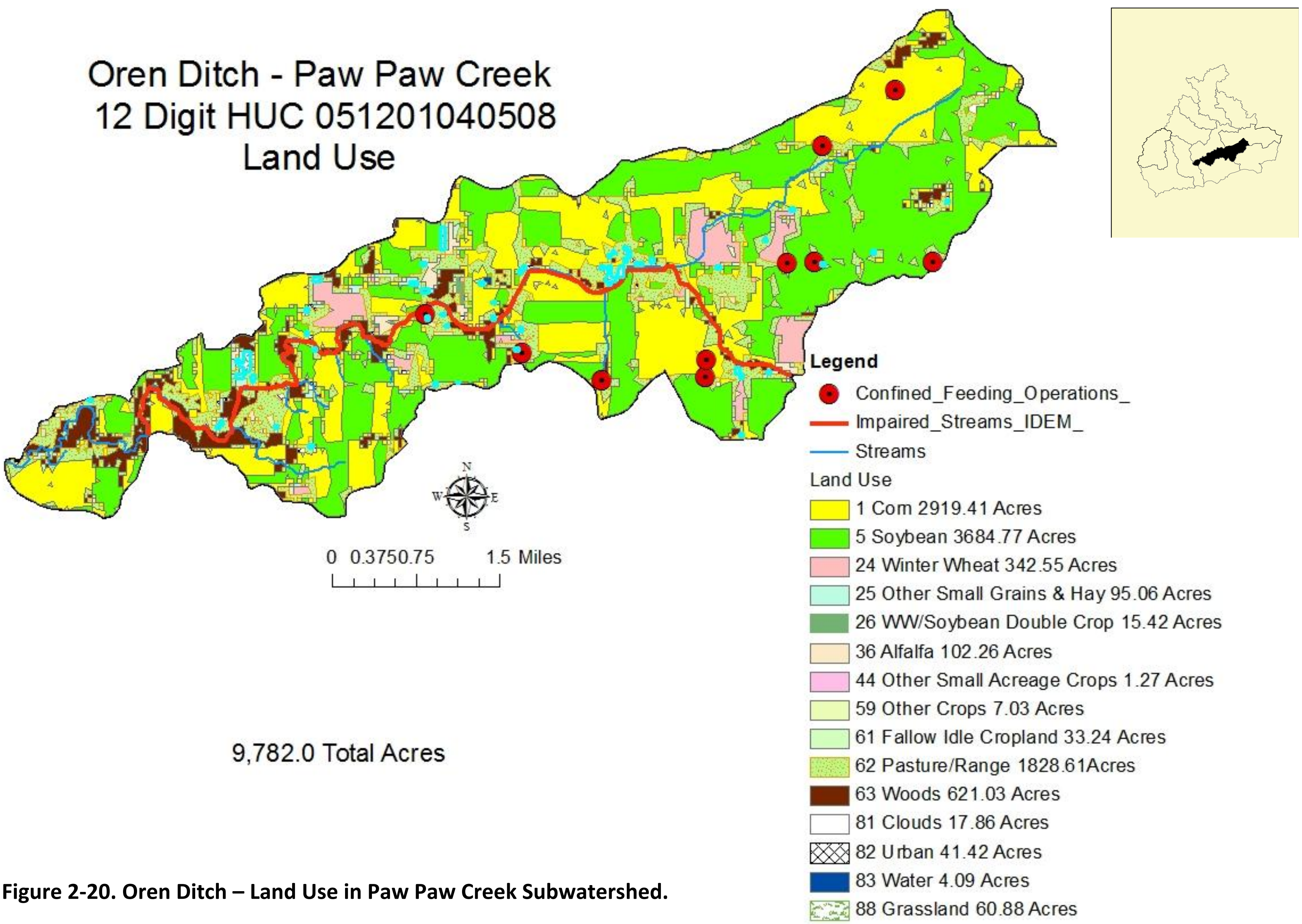

Figure 2-20. Oren Ditch – Land Use in Paw Paw Creek Subwatershed.

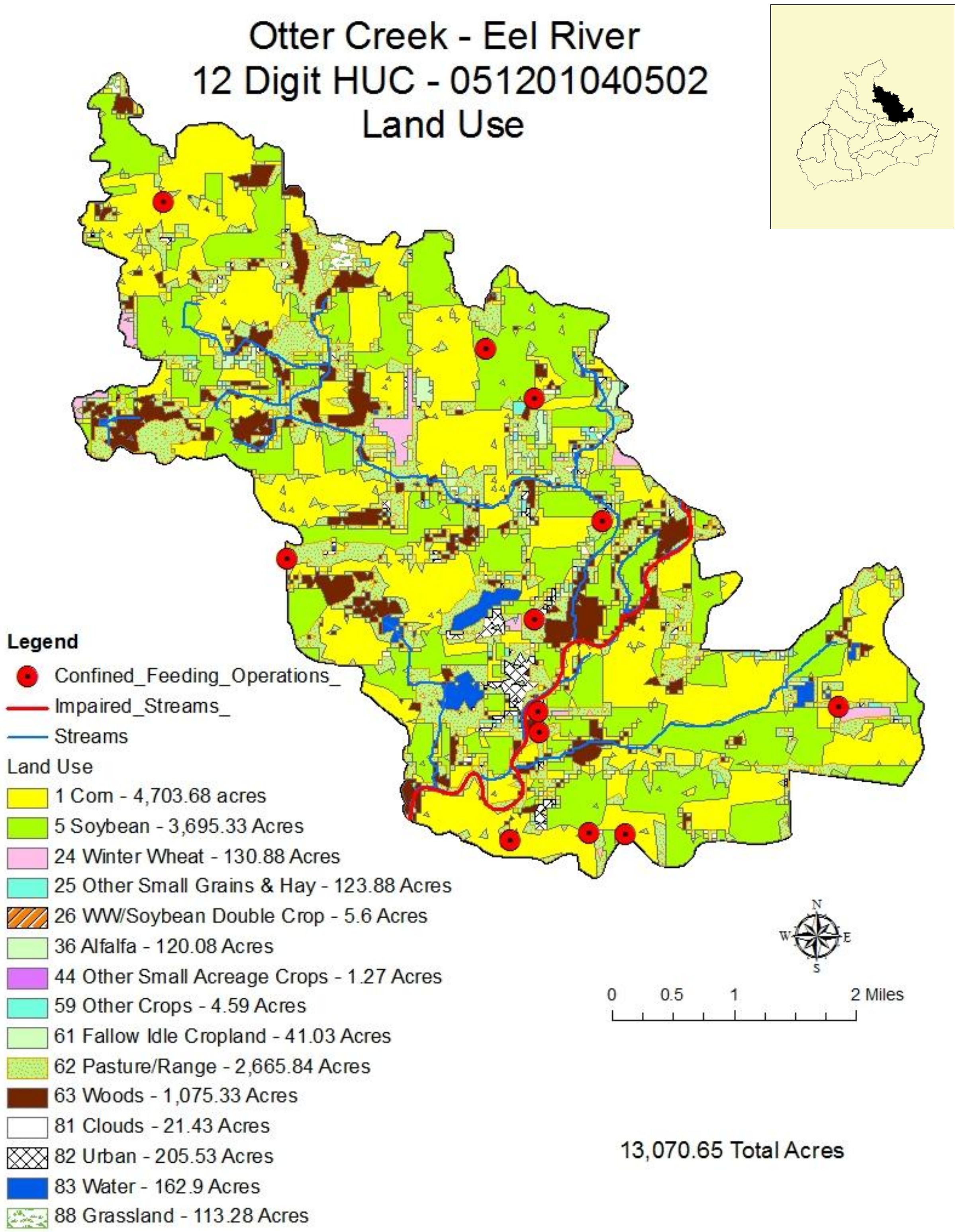

Figure 2-21. Land Use in Otter Creek – Eel River Subwatershed.

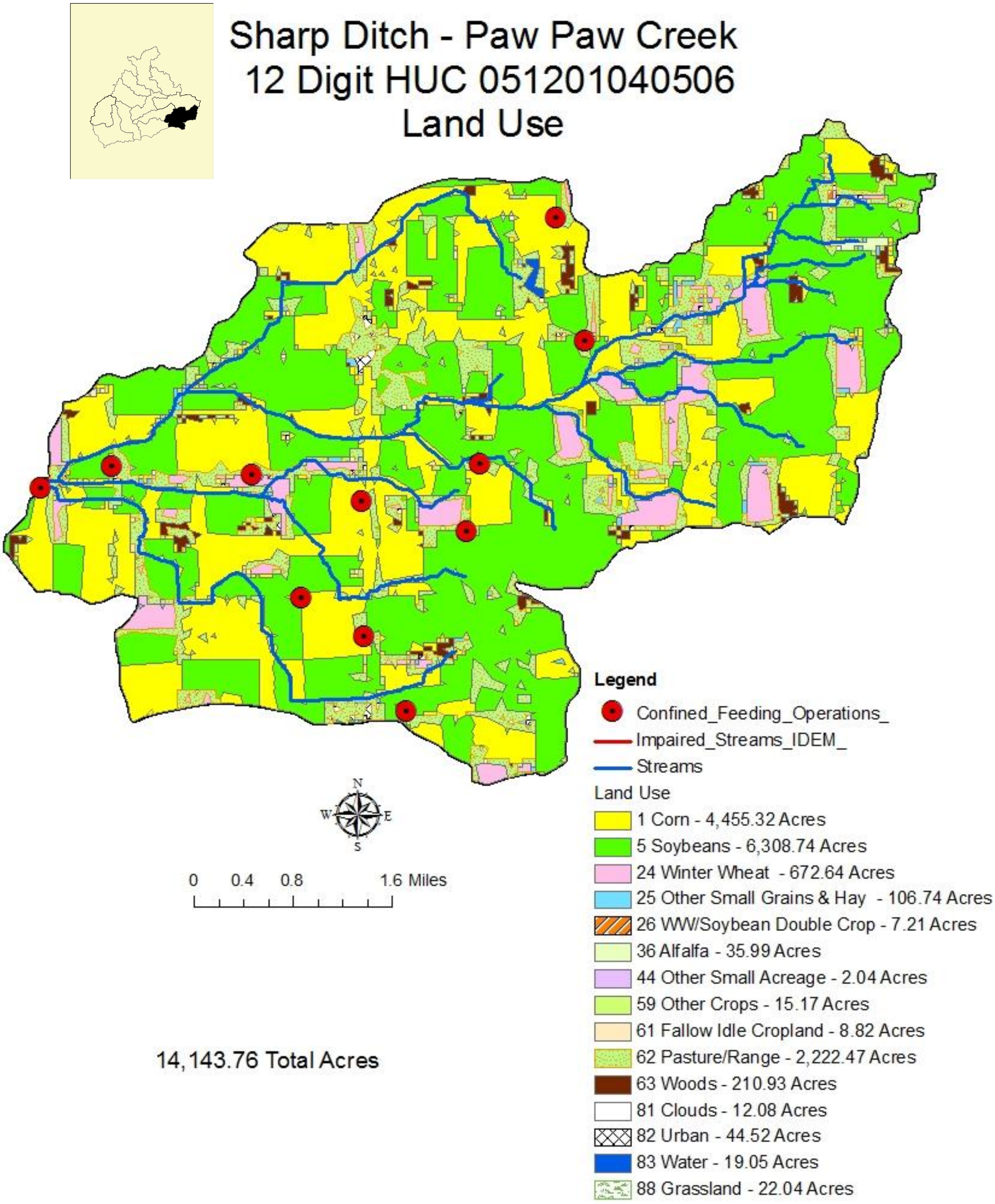

Figure 2-22. Land Use in Sharp Ditch – Paw Paw Creek Subwatershed.

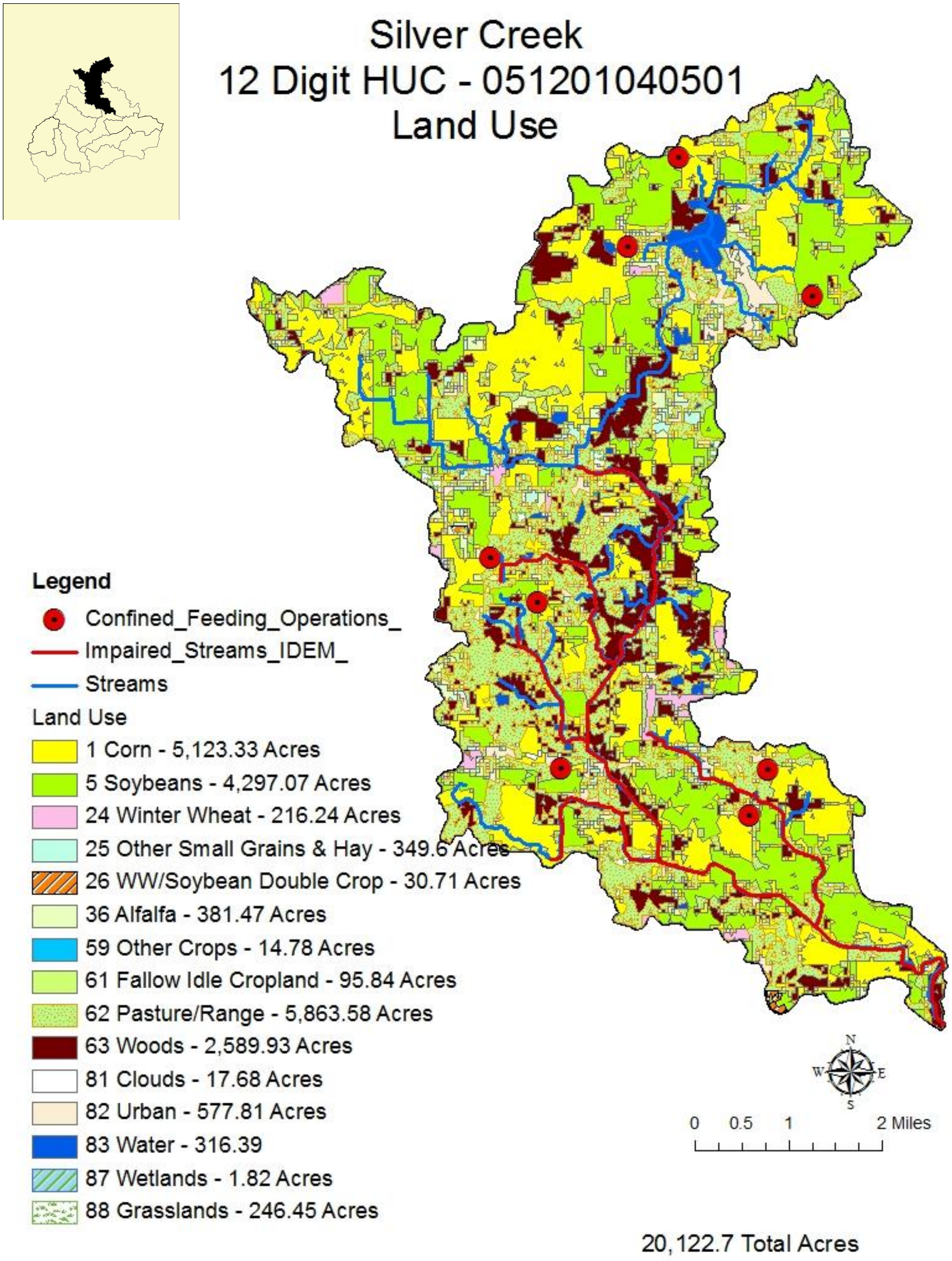

Figure 2-23. Land Use in Silver Creek Subwatershed.

Figure 2-24. Silver Creek, cattle are free to wade in the creek. Livestock access to streams is typical throughout the Middle Eel River Watershed. Photo by Craig Colvin, 2009.

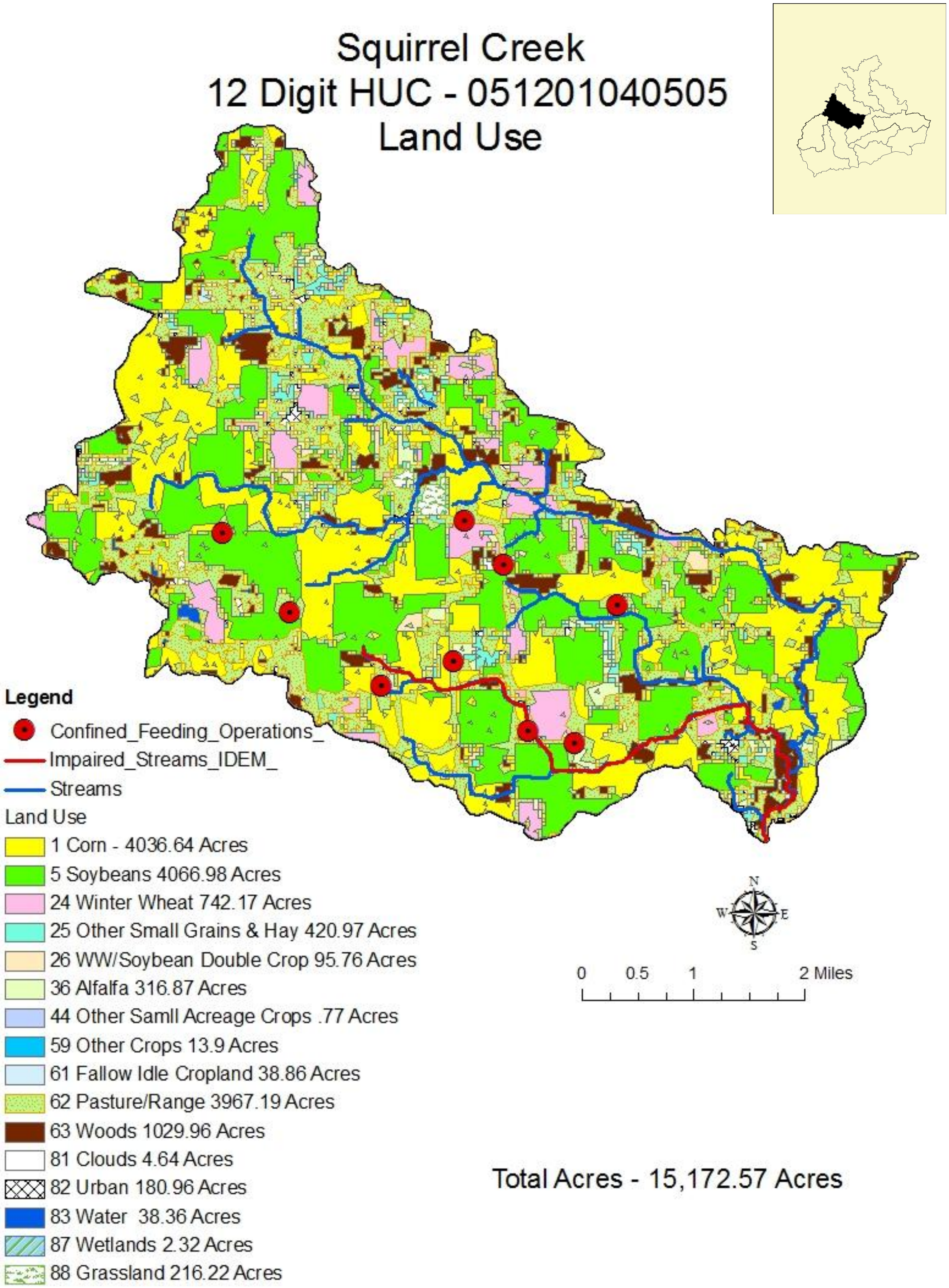

Figure 2-25. Land Use in Squirrel Creek Subwatershed

Figure 2-26. Erosion in Squirrel Creek –cattle have full access to stream and drainage tile present, the pasture empties directly into the creek, thus easy transport for pathogens and nutrients. Photo by Craig Colvin, 2009.

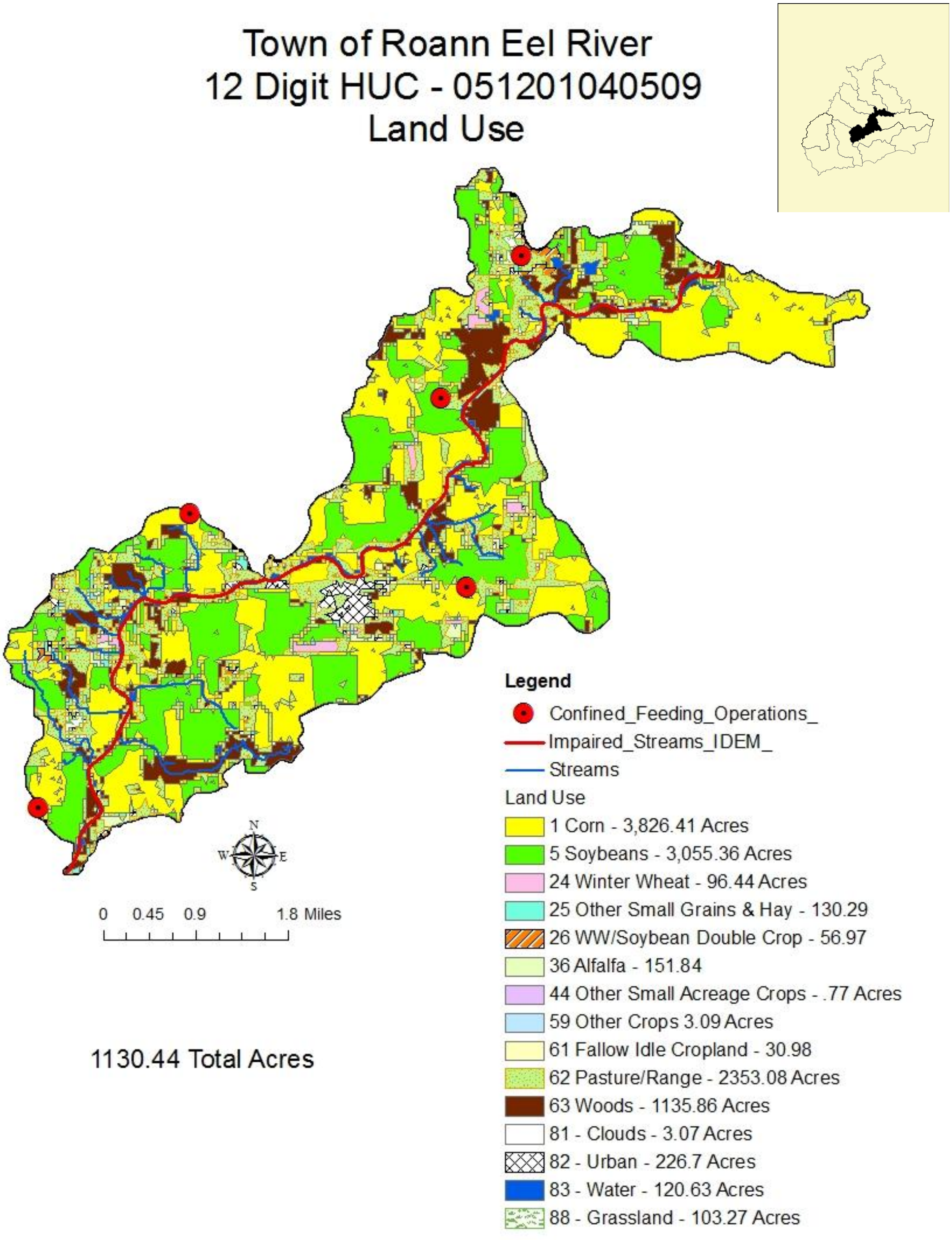

Figure 2-27. Land Use in Town of Roann – Eel River Subwatershed

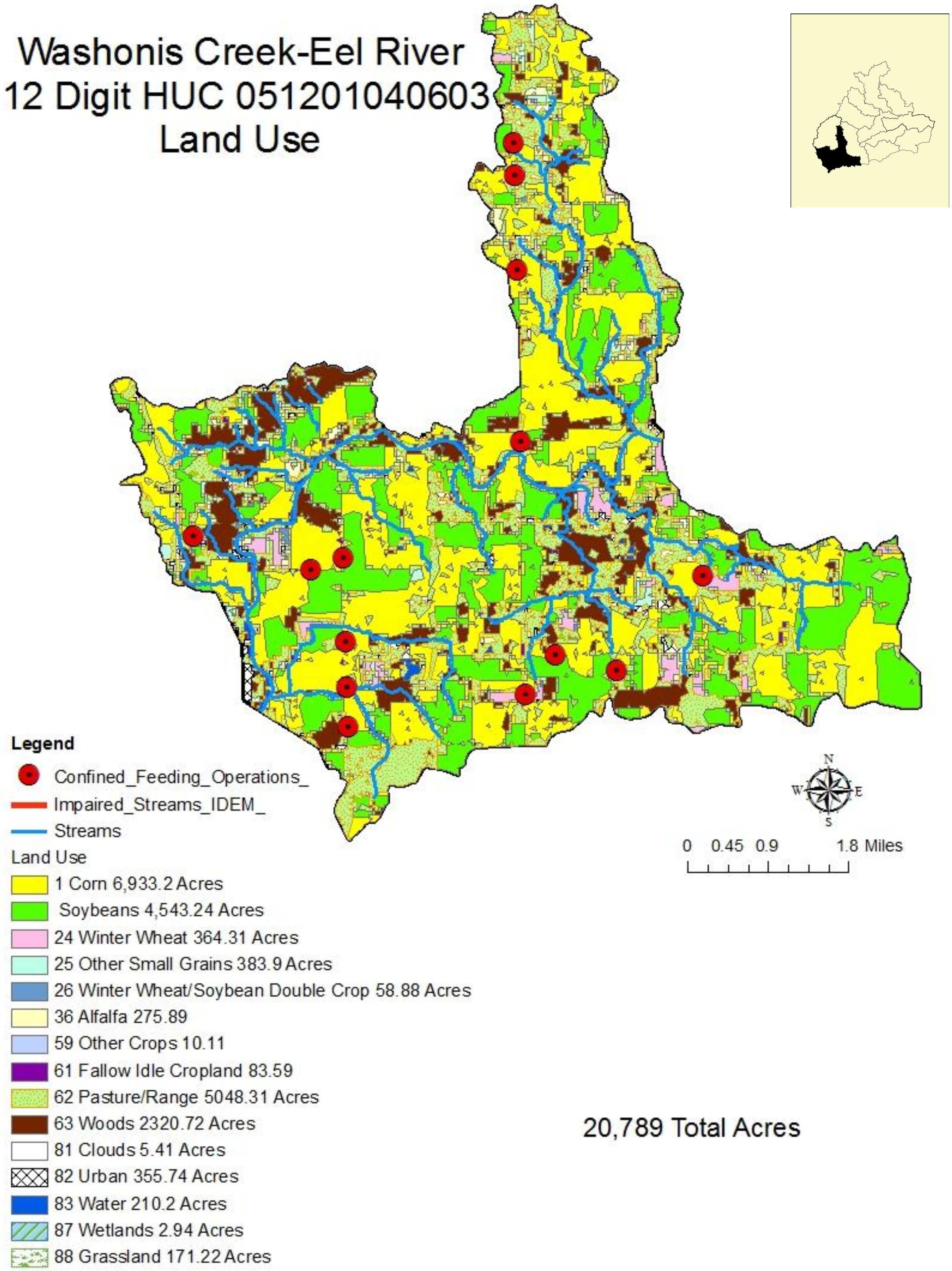

Figure 2-28. Land Use in Washonis Creek – Eel River Subwatershed

Figure 2-29. Laying subsurface tile drains (field tile) in Silver Creek Subwatershed, a typical practice throughout the Middle Eel River Watershed.

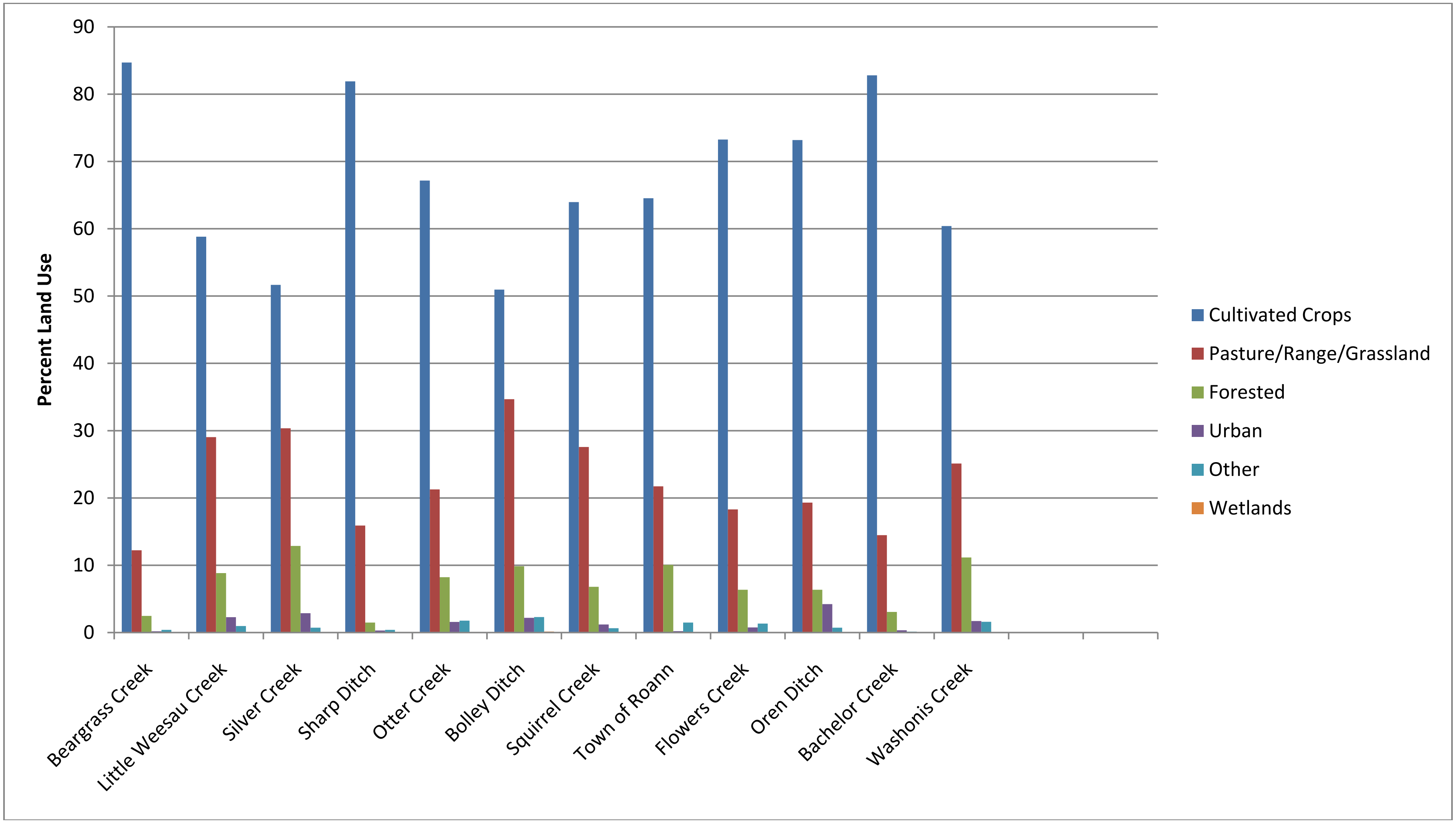

Figure 2-30. Land cover by percent of the 12 Digit HUC subwatersheds. Land cover categories were grouped into the following six categories: Cultivated Crops (corn, soybeans, winter wheat, hay and alfalfa), Pasture/Range/Grasslands, Forested, Urban, Wetlands and Other (other small acreage crops, fallow cropland, clouds, and open water).

2.8.1 –Tillage Practices

Conservation tillage is any tillage and planting system that covers 30 percent or more of the soil surface with crop residue, after planting, to reduce soil erosion by water. Two key factors influencing crop residue are (1) the type of crop, which establishes the initial residue amount and its fragility, and (2) the type of tillage operation prior to and including planting (USDA 2000).

Conservation Tillage Systems Include (USDA 2000):

No-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. Weed control is accomplished primarily with herbicides. Cultivation may be used for emergency weed control.

Ridge-till—The soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation.

Mulch-till—The practice of managing the amount, orientation and distribution of plant residues on the soil surface throughout the year round. The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps, or blades are used. Weed control is accomplished with herbicides and/or cultivation.

Reduced tillage (15-30% residue)—Tillage types that leave 15-30 percent residue cover after planting, or 500-1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Weed control is accomplished with herbicides and/or cultivation.

Conventional Tillage (USDA 2000):

Conventional tillage (less than 15% residue)—Tillage types that leave less than 15 percent residue cover after planting, or less than 500 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Generally includes plowing or other intensive tillage. Weed control is accomplished with herbicides and/or cultivation. Conventional tillage systems include:

Conventional tillage with moldboard plow—Any tillage system that includes the use of a moldboard plow.

Conventional tillage without moldboard plow—Any tillage system that has less than 30 percent remaining residue cover and does not use a moldboard plow.

There are numerous benefits to a no-till system, according to Purdue University (Conservation Technology Information Center 2006), the top ten benefits of no-till are:

Reduces labor, saves time – As little as one trip for planting compared to two or more tillage operations means fewer hours on a tractor and fewer labor hours to pay…or more acres to farm. For instance, on 500 acres the time savings can be as much as 225 hours per year. That's almost four 60-hour weeks.

Saves fuel – Save an average 3.5 gallons an acre or 1,750 gallons on a 500 acre farm.

Reduces machinery wear – Fewer trips save an estimated $5 per acre on machinery wear and maintenance costs – a $2,500 savings on a 500 acre farm.

Improves soil tilth – A continuous no-till system increases soil particle aggregation (small soil clumps) making it easier for plants to establish roots. Improved soil tilth also can minimize compaction. Of course, compaction is also reduced by reducing trips across the field.

Traps soil moisture to improve water availability – Keeping crop residue on the surface traps water in the soil by providing shade. The shade reduces water evaporation. In addition, residue acts as tiny dams slowing runoff and increasing the opportunity for water to soak into the soil. Another way infiltration increases is by the channels created by earthworms and old plant roots. In fact, continuous no-till can result in as much as two additional inches of water available to plants in late summer.

Reduces soil erosion – Crop residues on the soil surface reduce erosion by water and wind. Depending on the amount of residues present, soil erosion can be reduced by up to 90% compared to an unprotected, intensively tilled field.

Improves water quality – Crop residue helps hold soil along with associated nutrients (particularly phosphorus) and pesticides on the field to reduce runoff into surface water. In fact, residue can cut herbicide runoff rates in half. Additionally, microbes that live in carbon rich soils quickly degrade pesticides and utilize nutrients to protect groundwater quality.

Increases wildlife – Crop residue provides shelter and food for wildlife, such as game birds and small animals.

Improves air quality – Crop residue left on the surface improves air quality because it: reduces wind erosion, thus it reduces the amount of dust in the air; reduces fossil fuel emissions from tractors by making fewer trips across the field; and reduces the release of carbon dioxide into the atmosphere by tying up more carbon in organic matter.

Tillage data for the Miami and Wabash County are displayed in Figures 2-31 and 2-32. No-till soybeans have been fairly well adopted within the watershed, however, no-till corn is still very limited (Indiana State Department of Agriculture, 2009).

Estimated acreage of conventional tillage corn in Wabash County is 18,779 acres and Miami County 11,465 acres. Estimated acreage of conventional tillage soybeans in Wabash County is 5,671 and Miami County 1,057. With the high percentage of agriculture within the watershed it is likely that conventional agricultural tillage may be contributing to excess sediment, nutrients and *E. coli* in the tributaries and mainstem of the Middle Eel River.

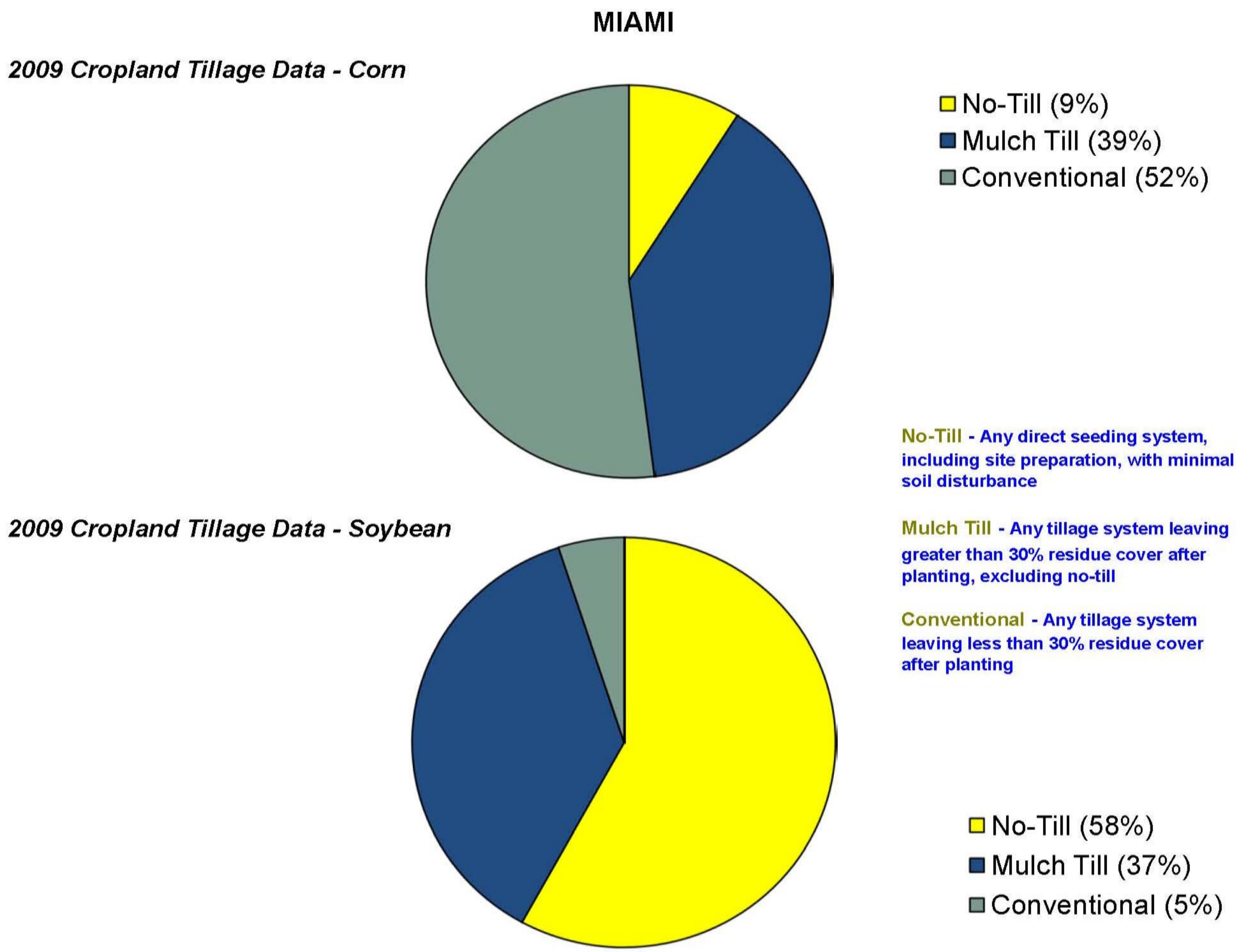

Figure 2-31. Tillage Data for Miami County, IN, 2009. Indiana State Department of Agriculture 2009.

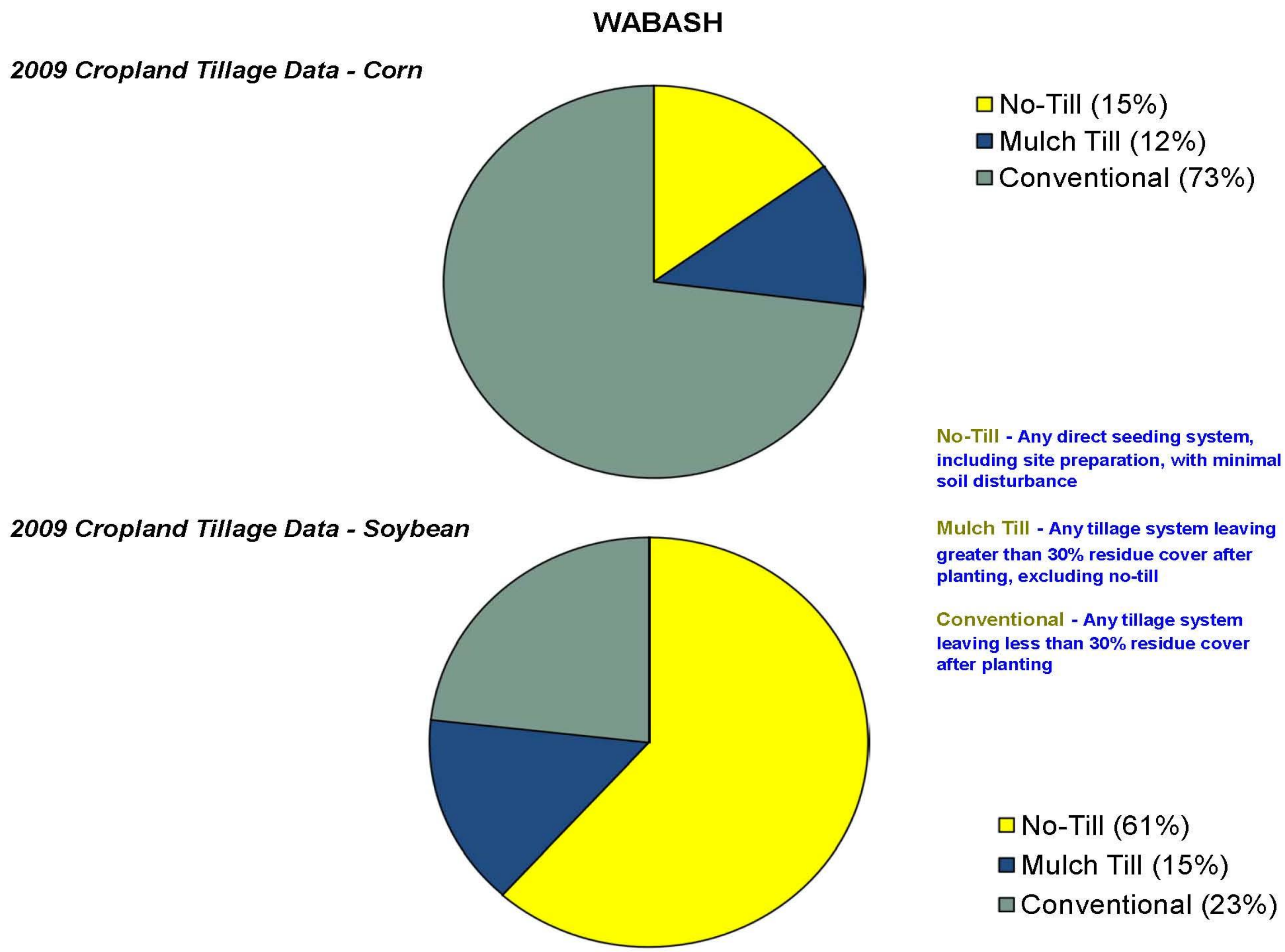

Figure 2-32. Tillage Data for Wabash County, IN, 2009. Indiana State Department of Agriculture

2.8.2 –Riparian Buffers

Riparian (along the waters' edge) buffers are extremely important to water quality. Conservation riparian buffers are small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns. Buffers include: riparian buffers, filter strips, grassed waterways, shelterbelts, windbreaks, living snow fences, contour grass strips, cross-wind trap strips, shallow water areas for wildlife, field borders, alley cropping, herbaceous wind barriers, and vegetative barriers.

Strategically placed buffer strips in the agricultural landscape can effectively mitigate the movement of sediment, nutrients, and pesticides within farm fields and from farm fields. When coupled with appropriate upland treatments, including crop residue management, nutrient management, integrated pest management, winter cover crops, and similar management practices and technologies, buffer strips should allow farmers to achieve a measure of economic and environmental sustainability in their operations. Buffer strips can also enhance wildlife habitat and protect biodiversity.

The literature shows that a 30 meter buffer strip is the most effective, "The most effective buffers are at least 30 meters, or 100 feet wide, composed of native forest, and are applied to all streams, including very small ones." (Wenger and Fowler 2000). Figure 2-33 displays the type of land use within a 30 meter riparian buffer of all streams within the Middle Eel River Watershed as a percentage. Land use was broken down into the following five categories: Row Crops, Grassland/Pasture, Urban, Wetlands, and Forest. Figures 2-34 through 2-38 show land use within a 30 meter buffer of all tributaries and the mainstem of the Eel River located in the Middle Eel River Watershed. It is important to note that in order to show land use in the buffers for the entire watershed, maps need to be zoomed out to a level that may cause the land use within the buffers to appear to overlap.

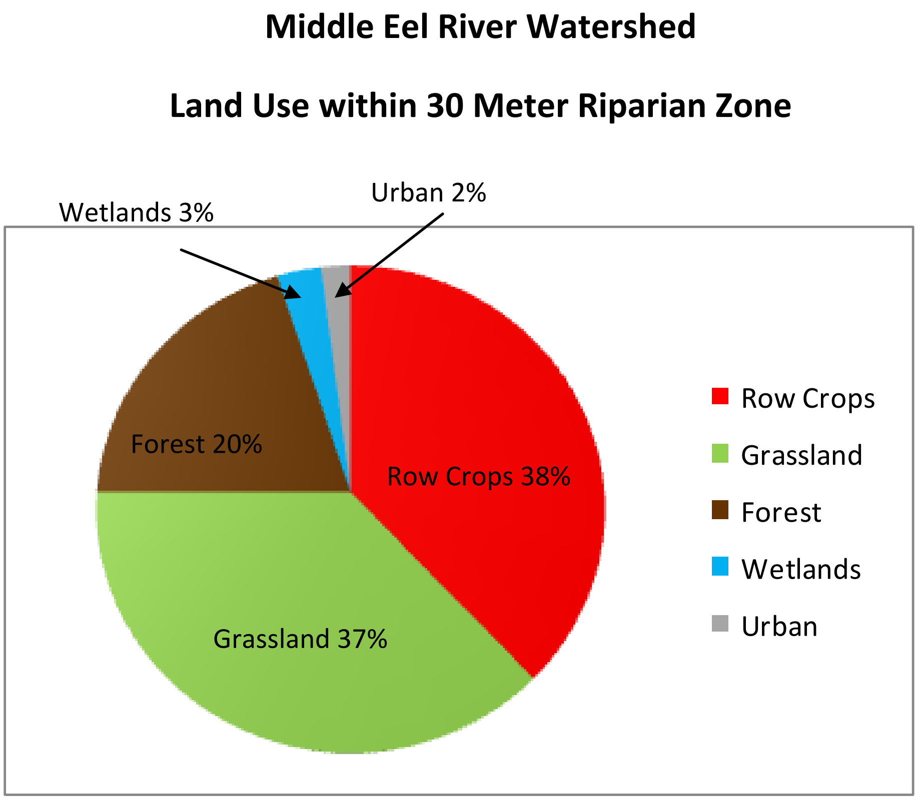

Figure 2-33. Land use within 30 meter riparian buffer of all streams within the Middle Eel River Watershed as a percentage of total land in the 30 meter buffer.

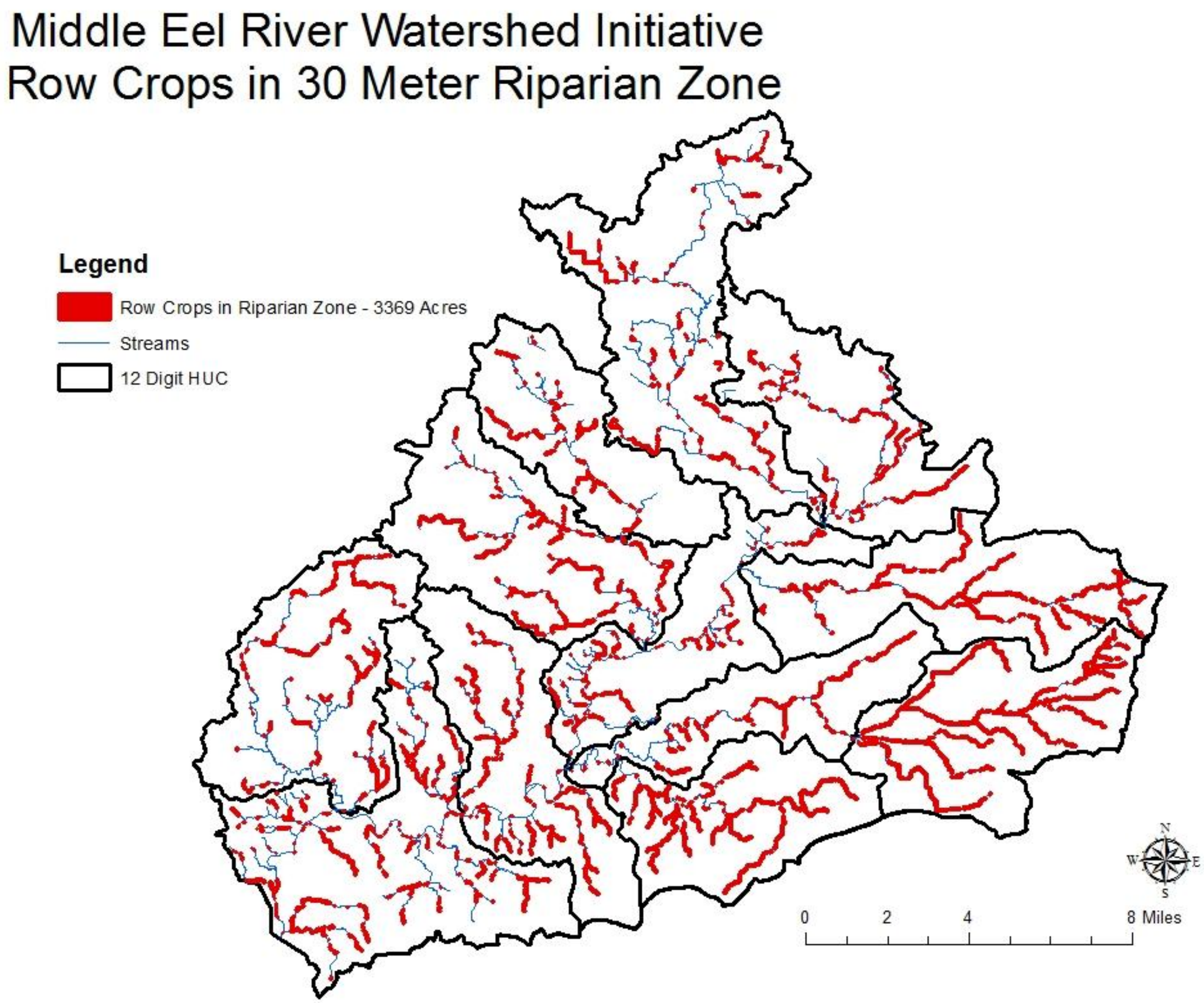

Figure 2-34. Row Crops within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

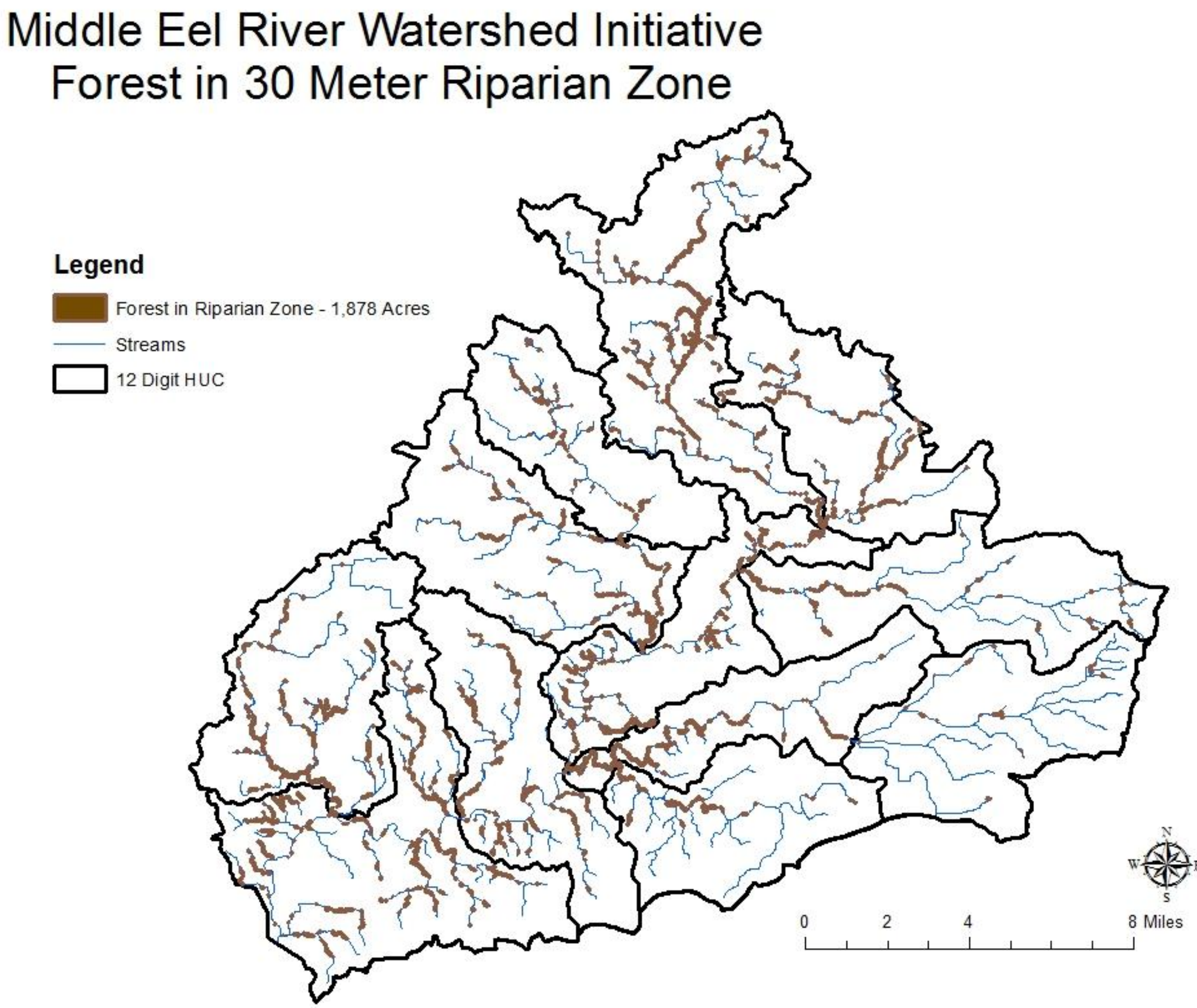

Figure 2-35. Forests within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

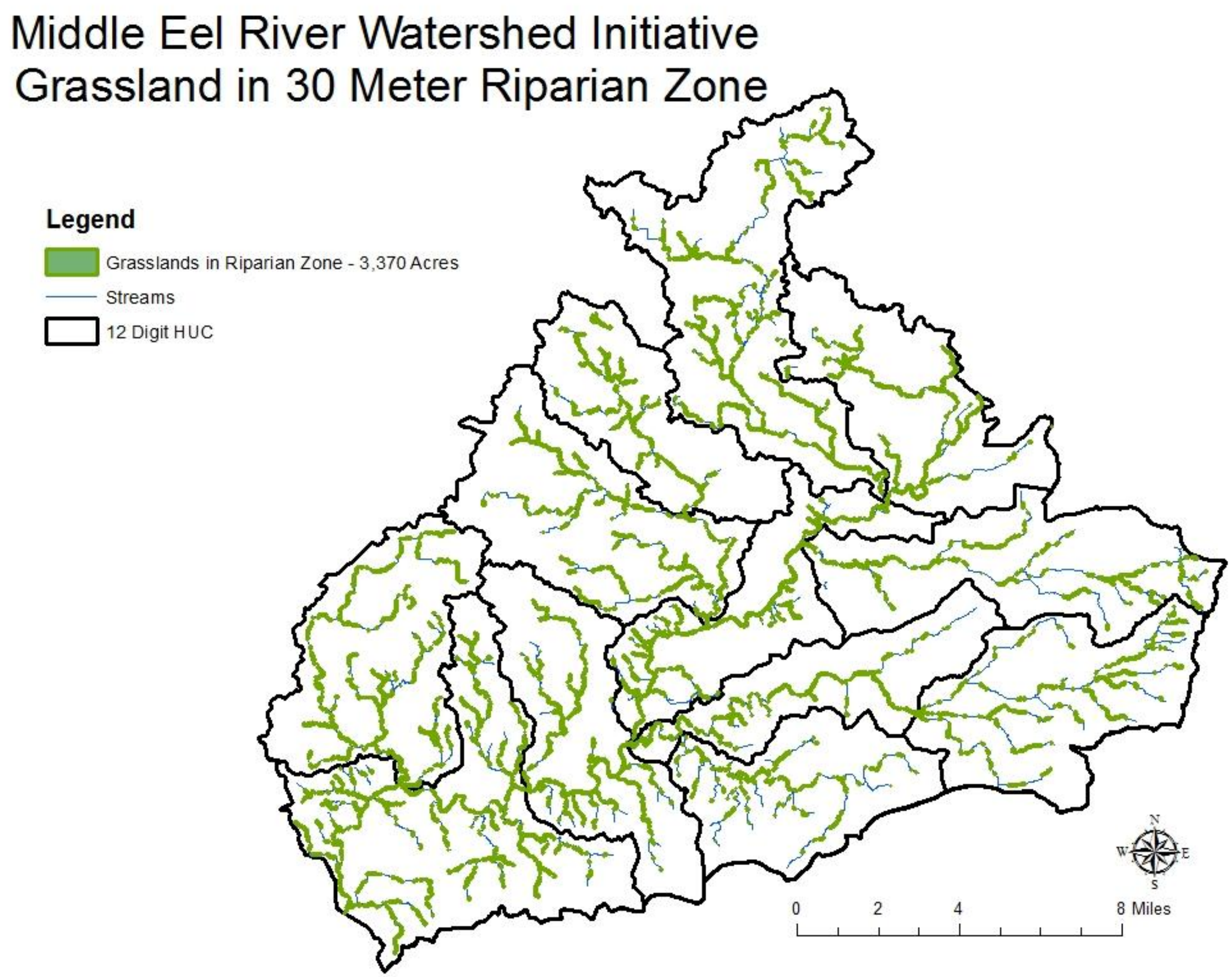

Figure 2-36. Grasslands within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

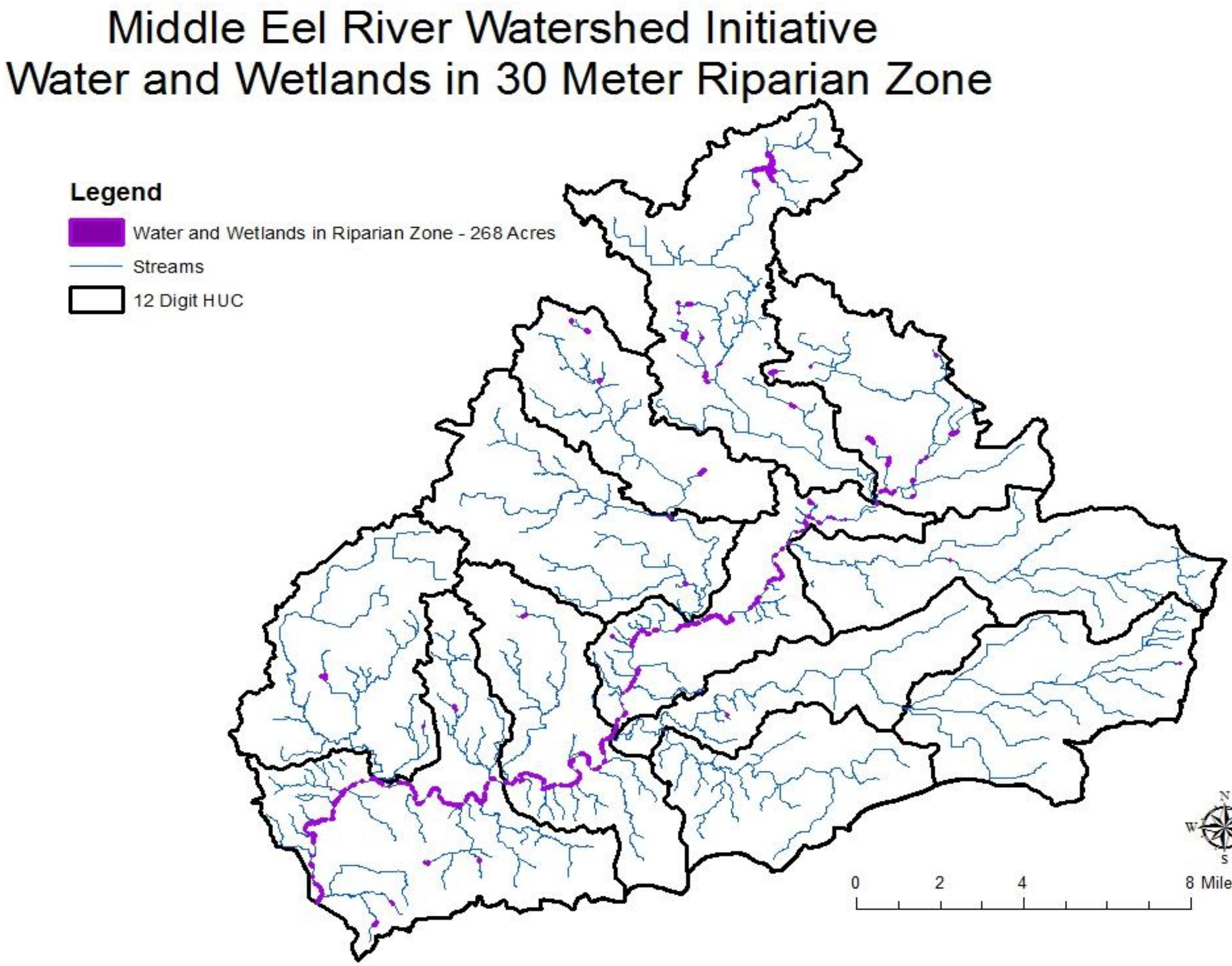

Figure 2-37. Wetlands & water within 30 meter riparian zone of all streams within the Middle Eel River Watershed.

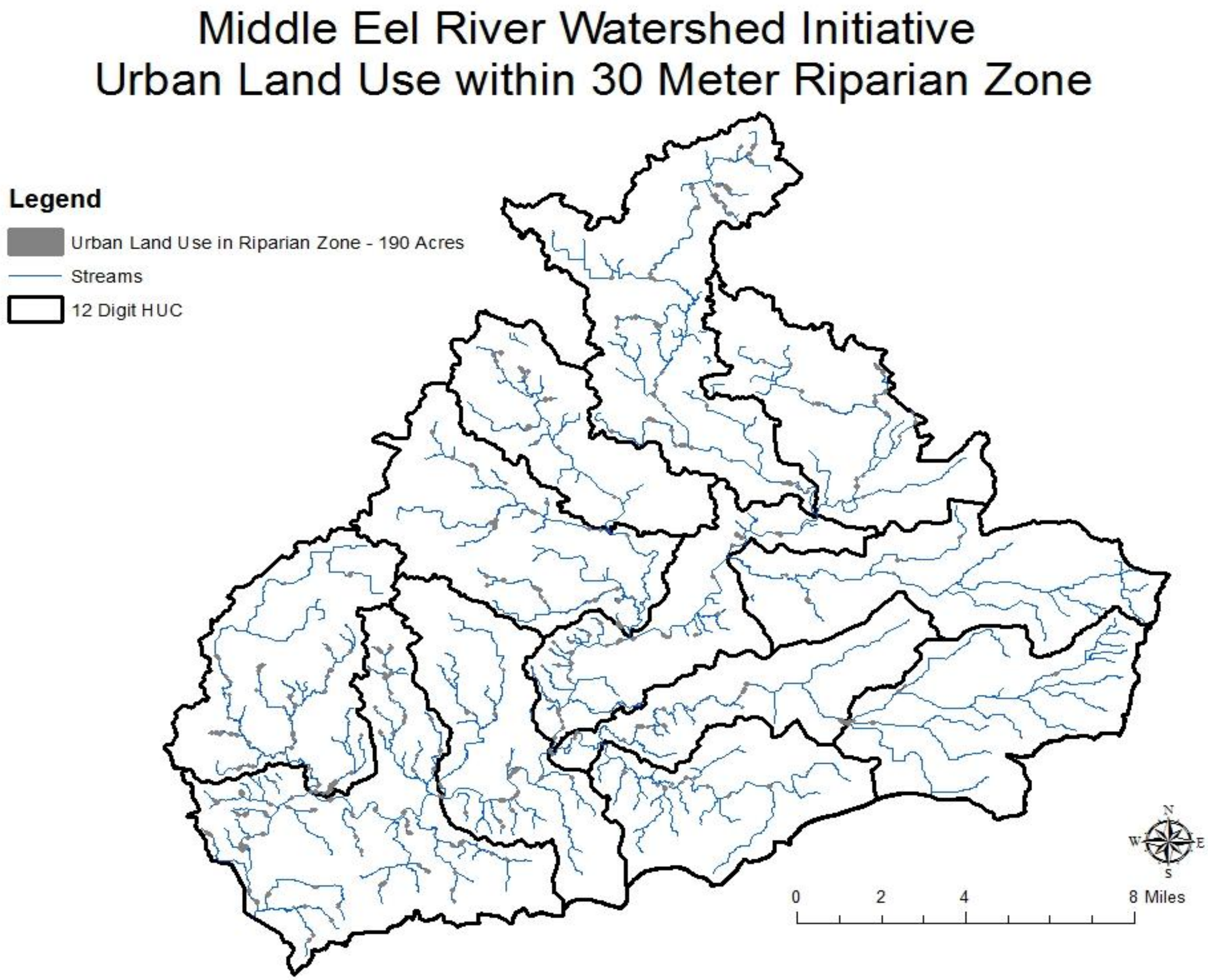

Figure 2-38. Urban areas within 30 meter riparian zone of all streams within the Middle Eel River

2.8.3 Impervious Cover

Impervious cover within the watershed is 2.84% using the Purdue Watershed Delineation model (Choi, J.Y., B. Engel and L. Theller, 2005). Estimation of impervious cover based on land use was recommended as an affordable approach by Cappiella and Brown (2001). The mean impervious cover based on land use that was used in estimating the impervious area in the watershed is presented in the Table 2-4 below. While impervious cover can create run-off problems in many areas, it is not a serious concern in the Middle Eel River Watershed due to the small amount of impervious cover within the watershed.

Table 2-4. Impervious Cover % Based on Land Use Category (Cappiella and Brown, 2001).

Land Use Category	Impervious Cover %
Agriculture, Pasture/Grass, Forest	1.9
Water/Wetland	0.0
Low Density Residential	15.4
High Density Residential	36.4
Industrial	53.4
Commercial	72.2

2.9 Hydrology

2.9.1 Stream Order

Stream order is a common stream classification system which helps describe a river's size and watershed area; the greater the stream order, the greater the size and watershed area. Using this system, the Eel River is a 5th order stream. A large number of first order streams are present in the watershed and most, if not all of these first order streams have been modified for agricultural drainage through straightening, ditching, dredging, and/or removal of riparian buffer areas. This has a direct influence on the amount of sedimentation, nutrients and E. coli reaching the streams. The drainage modifications do not only affect first order streams, however, first order streams comprise the majority of the watershed in terms of stream miles, and are where the largest amount on nonpoint source pollution enters the streams.

2.9.2 Stream Modification

According to the US Environmental Protection Agency's National Water Quality Inventory: Report to Congress (2004), hydromodification is the second leading cause of nonpoint source pollution in our rivers and streams. Hydromodification includes the laying of field tile, ditch maintenance, dam installation, and stream channelization in the tributaries. From the town of Collamer in Whitley County to its source in Allen County, the mainstem of the Eel River is considered a legal drain and has been channelized resulting in degraded biotic habitats (Henschen 1987). From North Manchester downstream the mainstem of the river has not been channelized (Henschen, 1987), however the watershed was extensively ditched and drained prior to 1900 for agricultural use (Gammon 1990). Extensive tile drainage and ditching continues to this day within the watershed. Dredging and debrushing of the open drains destroys habitat, increases suspended sediment and nutrients, and is expensive to maintain. Stream modification, driven by agriculture, is a major contributing factor to nonpoint source pollution in the watershed.

Lowhead dams are one of the main sources of disturbance on streams. Dams convert free flowing streams to stillwaters, changing the flow regime, physical stream characteristics, increasing siltation upstream and causing scouring down stream, altering fish assemblages, and blocking host fishes. Low head dams can alter the freshwater mussel fauna, including restricting distributions and isolating populations, reducing native species richness and abundance, increasing non-native species richness and abundance (Tiemann et al. 2007).

Low head dams were historically constructed at various locations on the Eel River to power mills, many of which are currently in disrepair (Gammon 1990). There is only one dam within the Middle Eel River Watershed on the mainstem that remains intact, the dam at the Stockdale Mill near Roann. The mill has been renovated and is historically significant. There are two other dams very near the watershed, one at North Manchester just upstream of the watershed break, and one in Mexico, IN, just downstream of the watershed break.

Dams have a negative impact on the natural ecology of the stream, resulting in large pooling areas in the river that would not naturally occur. The Eel River is a low gradient stream dropping only approximately 2.41 feet per mile, consequently water backs up for approximately 2.5 miles for each foot of dam height (Gammon, 1990). In addition to changing the natural flow of the river, it also creates a barrier for genetic diversity and host species for mussel reproduction, resulting in a depressed fish and mussel community.

There are control dams at Silver Lake, Lukens Lake, Long Lake and Dean Gifford Pond. These dams have been installed to control the water level in the lakes.

Dams maintained by the state within the Middle Eel River Watershed are shown in Figure 2.39.

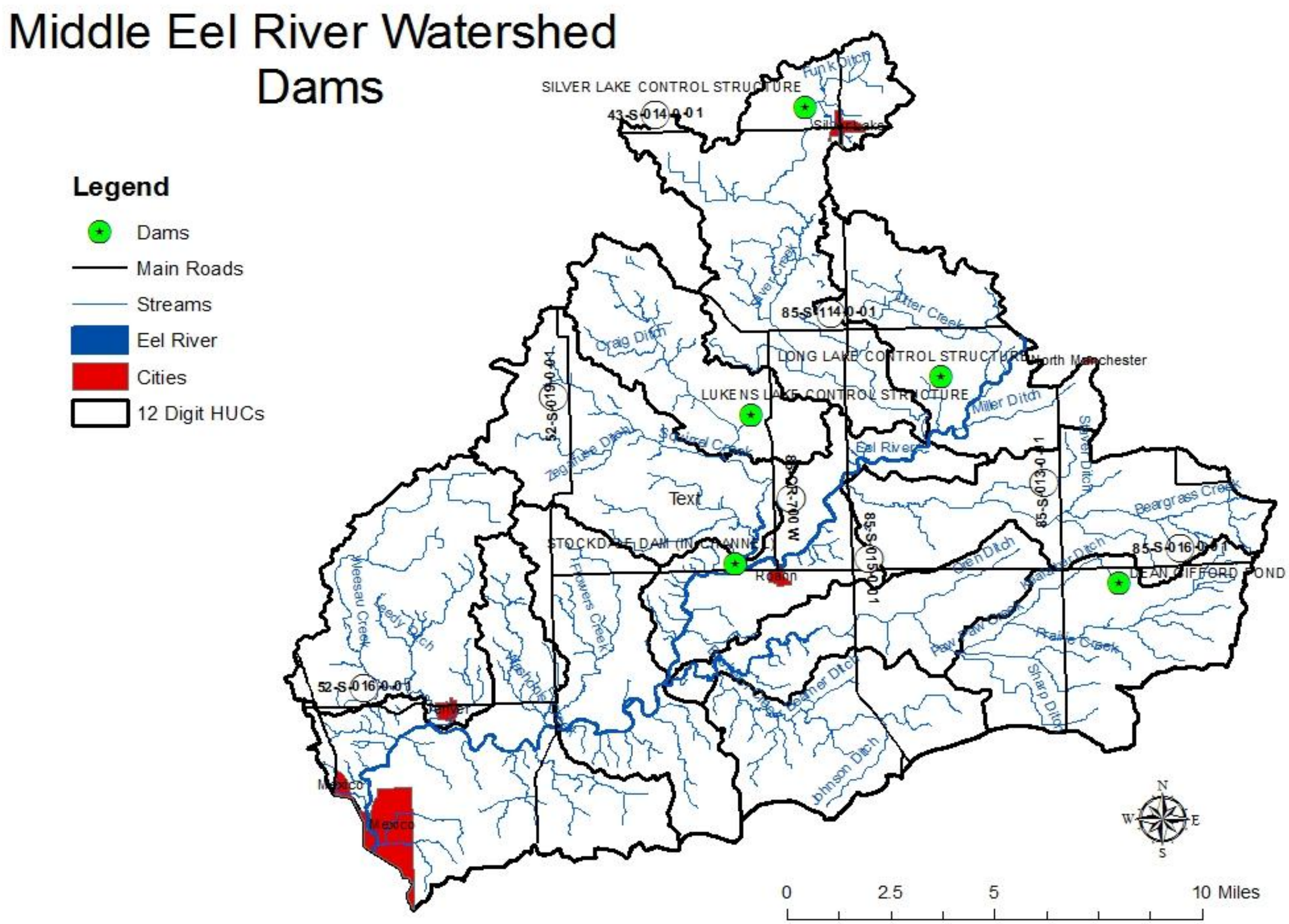

Figure 2-39. Middle Eel River Watershed Dam Locations.

2.9.3 Major Tributaries

The major tributaries of the Eel River within the watershed are listed in Table 2-5 along with stream length in miles and shown in Figure 2-40. These tributaries have very few areas of natural running stream length and are almost completely modified due to agricultural land use, resulting in changes in the hydrology of the watershed. These hydrological changes in the landscape have a negative impact on the river, including increased flooding, increased nutrients entering the stream, and increased sediment entering the river.

Table 2-5. Middle Eel River Watershed – Major Tributaries, Geographic Name and Length in Stream Miles.

Major Tributary Name	Length (stream miles)
Silver Creek	18.22
Beargrass Creek	12.20
Squirrel Creek	9.92
Paw Paw Creek	18.32
Flowers Creek	5.51
Weesau Creek	13.86

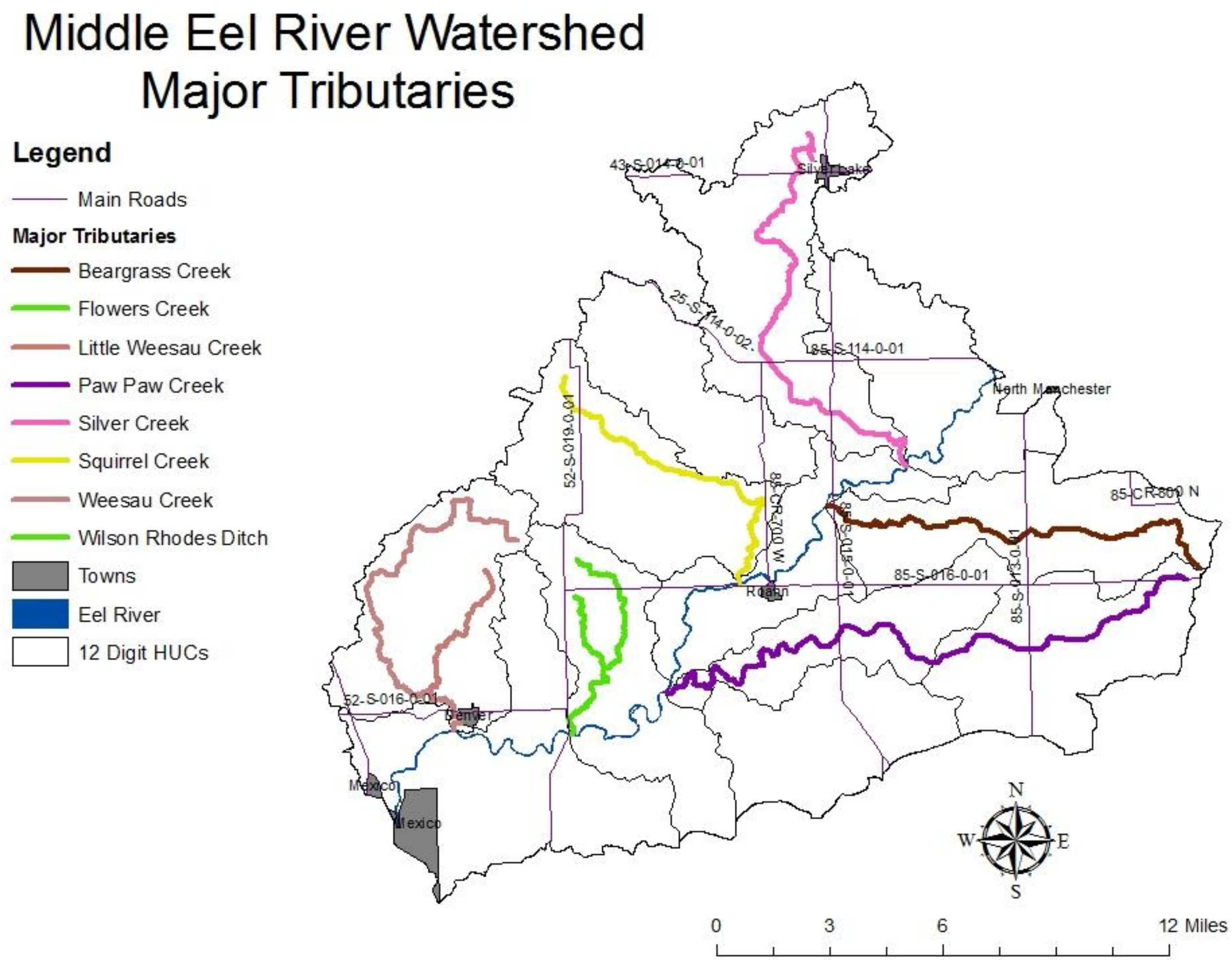

Figure 2-40. Middle Eel River Watershed – Location of Major Tributaries.

2.9.4 Lakes

The majority of lakes within the watershed are located in the most northeastern part of the watershed. The largest lake in the watershed is Silver Lake that covers 120.3 acres, and the smallest is Gaerte Lake that covers 4.45 acres. All lakes in the Middle Eel River Watershed are located within three 12 digit HUCs: 051201040501, 051201040502, and 051201040504, the three most northern 12 digit HUCs. The largest lakes, area in acres, and 12 digit HUC location are listed in Table 2-6 below, and shown in Figure 2-41.

Lakes serve many functions in a watershed; they store water, thereby helping to regulate stream flow; recharge ground water aquifers; moderate droughts; and serve as sinks and sediment traps. They provide habitat to aquatic and semiaquatic plants and animals, which in turn provide food for many terrestrial animals; and they add to the diversity of the landscape. Lakes are used by humans for many commercial purposes, including fishing, transportation, irrigation, industrial water supplies, and receiving waters for wastewater effluents.

Table 2-6. Middle Eel River Watershed Lakes, Names, Area in Acres, 12 digit HUCs, Lake Perimeter (Ft), % of Perimeter forested, grassed/row crop, or developed.

Lake Name	Acres	12 Digit HUC	Lake Perimeter (Ft)	% of Perimeter Forested	% of Perimeter Grass/row crop	% or Perimeter Developed
Brown Lake	9.14	51201040501	3,301	84%	16%	0%
Bull Lake	5.93	51201040501	2,310	0%	100%	0%
Flat Lake	6.92	51201040501	239	0%	100%	0%
Lotz Lake	10.38	51201040501	2,503	50%	50%	0%
North Little Lake	12.35	51201040501	2,710	100%	0%	0%
Silver Lake	120.34	51201040501	24,130	12%	1%	87%
South Little Lake	5.93	51201040501	2,982	18%	0%	82%
Twin Lakes	10.62	51201040501	5,438	41%	59%	0%
Bear Lake	4.94	51201040502	17,621	100%	0%	0%
Long Lake	47.44	51201040502	8,184	0%	28%	62%
Mud Lake	10.13	51201040502	2,703	100%	0%	0%
Round Lake	48.43	51201040502	6,758	0%	49%	51%
Gaerte Lake	4.45	51201040504	1,213	56%	44%	0%
Landis Lake	12.35	51201040504	2,992	0%	100%	0%
Lukens Lake	46.7	51201040504	6,494	36%	0%	64%
McColley Lake	28.17	51201040504	5,691	97%	3%	0%
Summit Lake	6.18	51201040504	2,323	0%	100%	0%
Upper Summit Lake	8.65	51201040504	2,776	74%	26%	0%
Total Acreage	**392.87**					

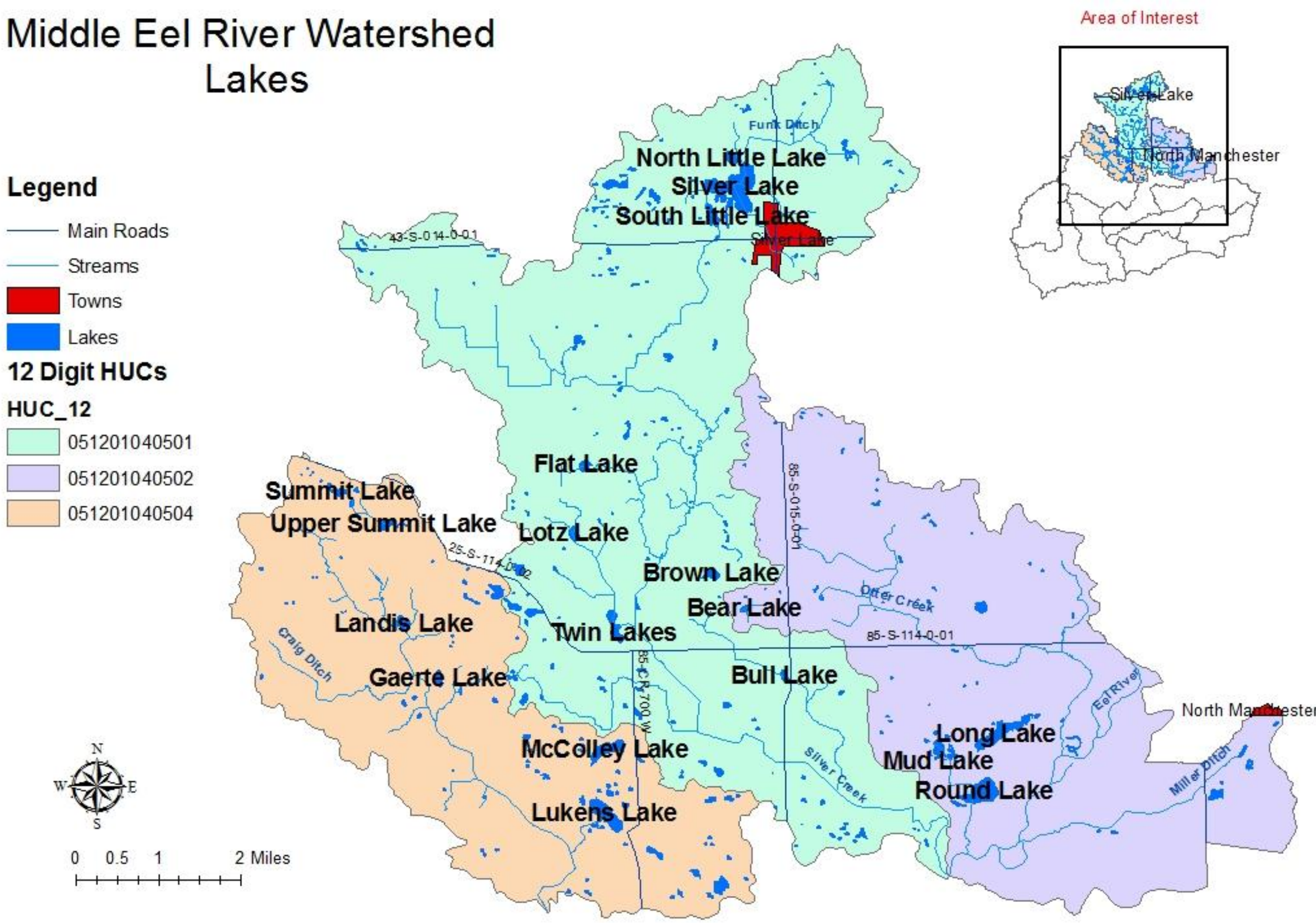

Figure 2-41. Lake of the Middle Eel River Watershed.

2.9.5 Wetlands

It is estimated that 24.1% of Indiana's surface was covered by wetlands before European settlement (Jackson, 1997). Indiana ranks fourth in the nation in percentage of wetlands lost, with an estimated 85% of wetlands lost. Much of Indiana's original wetlands were concentrated in northeastern Indiana. The Middle Eel River Watershed contains approximately 1,974 acres of wetlands, lakes, streams, ponds and other water resources, which cover only 1.35% of the watershed.

According to USDA-NRCS soil data, 63,709 acres of the watershed have hydric soils. The acreage of hydric soils provides a rough estimate of the acreage that may have historically been wetlands. Current wetland acreage compared to hydric soils indicates a loss of 32.3% of wetlands within the watershed. Hydric acres within each county and percent of watershed are listed in Table 2-7. By using this information, it is estimated that historically 12% of the Watershed was water and wetlands.

Table 2-7. Hydric Soils, Acreage and Percent of watershed by county within the Middle Eel River Watershed.

County	Hydric Acreage	% of watershed
Kosciusko County	8,315	1.57%
Miami County	19,918	3.76%
Wabash County	35,476	6.69%
TOTAL	63,709	12.02%

The wetlands that remain in the Middle Eel River Watershed are very small areas that are widely scattered. The most concentrated area of wetlands is in the northeastern section of HUC 0512010405 as shown in Figure 2-42.

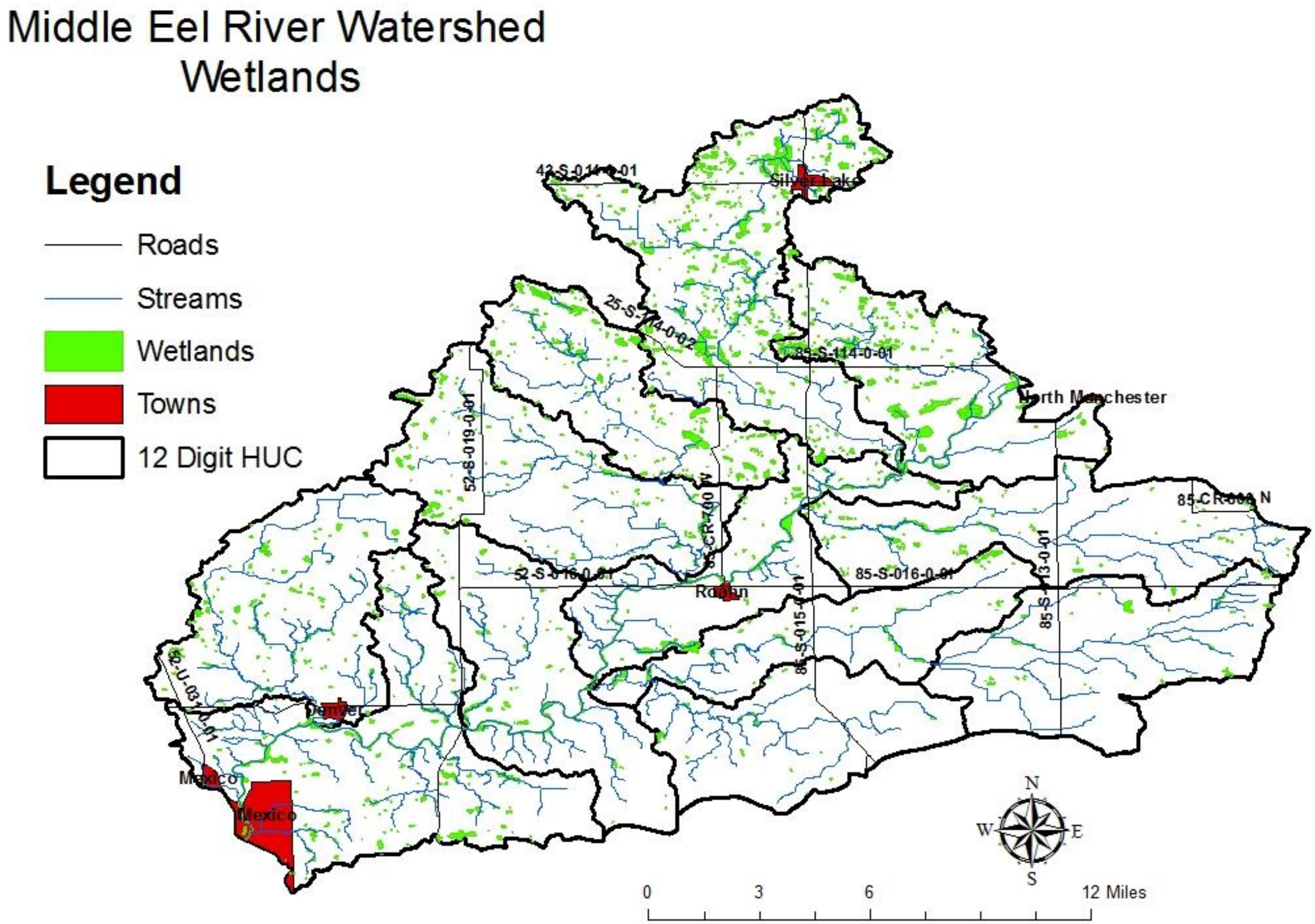

Figure 2-42. Wetlands in the Middle Eel River Watershed.

2.10 Threatened and Endangered Species

The Indiana Department of Natural Resources (IDNR) maintains information on threatened and endangered species. The IDNR posts lists for each county, however, specific locations of these species is not available. Since specific locations of these species are not available, we must assume that since the Middle Eel River Watershed encompasses large portions of both Miami and Wabash Counties, that it is possible for any of the listed species to occur within the watershed. The Indiana Endangered, Threatened and Rare Species Lists for Miami County (Table 2-8.) and Wabash County (Table 2-9.) are included below.

Table 2-8. Miami County Indiana, Endangered, Threatened and Rare Species List (Indiana Department of Natural Resources 2005).

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsillis fasciola	Wavyrayed lampmussel		SSC	G4	S2
Lampsillis teres	Yellow Sandshell			G5	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrical cylandrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Venustaconcha elipsiformis	Ellipse		SSC	G3G4	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Fish					
Ammocrypta pellucid	Eastern Sand Darter			G3	S2
Moxostoma valenciennesi	Greater Redhorse		SE	G4	S2
Reptile					
Emydoidea blandingi	Blanding’s Turtle		SE	G4	S2
Thamnophis proximus	Western Ribbon Snake		SSC	G5	S3
Bird					
Ardea Herodias	Great Blue Heron			G5	S4B
Circus cyaneus	Northern Harrier		SE	G5	S2
Mammal					
Lynx rufus	Bobcat	No Status		G5	S2
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Crataegus succulent	Fleshy Hawthorn		SR	G5	S2
Hypericum pyramidatum	Great St. John’s-wort		SR	G3	S2
Napaea dioica	Glade Mallow		SR	G3	S2
High Quality Natural Community					
Forest- upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest – upland-mesic	Mesic Upland Forest		SG	G3?	S3

LEGEND: FED: LE = Endangered; LT **LEGEND: FED:** LE = Endangered; LT = Threatened; C = Candidate; PDL = proposed for delisting
STATE: SE = State Endangered; ST State Threatened; SR = State Rare; SSC = State Species of Special Concern; SX = State Extirpated; SG = State Significant; WL = Watch List
GRANK: Global Heritage Rank: G1 = Critically Imperiled Globally; G2 = Imperiled Globally; G3 = Rare or Uncommon Globally; G4 = Widespread and abundant globally but with long term concerns; G5 = Widespread and abundant globally; G? = unranked; GX = Extinct; Q = Uncertain Rank; T = Taxonomic Subunit Rank
SRANK: State Heritage Rank: S1 = Critically Imperiled in State; S2 Imperiled in State; S3 = Rare or Uncommon in State; S4 = Widespread and abundant in state but with long term concern; SG = State Significant; SH = Historical in State; SX = State Extirpated; B = Breeding Status; S? = Unranked; SNR = Unranked; SNA = Nonbreeding Status Unranked

Table 2-9. Wabash County Indiana, Endangered, Threatened and Rare Species List (Indiana Department of Natural Resources 2005).

Species Name	Common Name	FED	STATE	GRANK	SRANK
Crustacean: Branchiopoda					
Lynceus brachyurus	Holarctic Clam Shrimp		WL	G5	S1?
Mollusk: Bivalvia (Mussels)					
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1	S1
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsillis teres	Yellow Sandshell			G5	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G3	S2
Quadrula cylindrical cylandrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Insect: Lepidoptera (Butterflies/ Moths)					
Calephelis muticum	Swamp Metalmark		ST	G3	S2
Euphydryas phaeton	Baltimore		SR	G4	S2
Euphyes bimacula	Two-spotted Skipper		ST	G4	S2
Euphyes dukesi	Scarce Swamp Skipper		ST	G3	S1S2
Fixsenia favonius	Northern Hairstreak		SR	G4	S1S2
Hesperia leonardus	Leonard's Skipper	No Status	SR	G4	S2
Lycaena epixanthe	Bog Copper		SX	G4G5	SX
Lycaena helloides	Purplish Copper		SR	G5	S2S4
Poanes viator viator	Big Broad-winged Skipper		ST	G5T4	S2
Speyeria idalia	Regal Fritillary		SE	G3	S1
Fish					
Ammocrypta pellucid	Eastern Sand Darter			G3	S2
Clinostomus elongates	Redside Dace		SE	G4	S1
Moxostoma valenciennesi	Greater Redhorse		SE	G4	S2

Species Name	Common Name	FED	STATE	GRANK	SRANK
Reptile					
Emydoidea blandingi	Blanding's Turtle		SE	G4	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Bird					
Ardea herodias	Great Blue Heron			G5	S4B
Buteo platypterus	Broad-winged Hawk	No Status	SSC	G5	S3B
Certhia americana	Brown Creeper			G5	S2B
Chlidonias niger	Black Tern		SE	G4	S1B
Circus cyaneus	Northern Harrier		SE	G5	S2
Dendroica cerulean	Cerulean Warbler		SSC	G4	S3B
Dendroica virens	Black-throated Green Warbler			G5	S2B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Rallus limicola	Virginia Rail		SE	G5	S3B
Sterna hirundo	Common Tern			G5	SXB
Tyto alba	Barn Owl		SE	G5	S2
Wilsonia citrine	Hooded Warbler		SSC	G5	S3B
Mammal					
Condylura cristata	Star-nosed Mole		SSC	G5	S2?
Lutra canadensis	Northern River Otter			G5	S2
Lynx rufus	Bobcat	No Status		G5	S2
Mustela nivalis	Least Weasal		SSC	G5	S2?
Myotis sodalist	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Arenaria stricta	Michaux's Stitchwort		SR	G5	S2
Carex flava	Yellow Sedge		ST	G5	S2
Carex lupuliformis	False Hop Sedge		SR	G4	S2
Cypripedium calceolus var. parviflorum	Small Yellow Lady's-slipper		SR	G5	S2
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Erysimum capitatum	Prairie-rocket Wallflower	No Status	ST	G5	S2
Schizachne purpurascens	Purple Oat		SE	G5	S1
Waldsteinia fragarioides	Barren Strawberry		SR	G5	S2
Zigadenus elegans var. glaucus	White Camas		SR	G5T4T5	S2

High Quality Natural Community					
Forest – flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2
Forest – floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest- upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest – upland-mesic	Mesic Upland Forest		SG	G3?	S3
Primary – cliff limestone	Limestone Cliff		SG	GU	S1
Wetland – fen	Fen		SG	G3	S3

LEGEND: FED: LE = Endangered; LT = Threatened; C = Candidate; PDL = proposed for delisting
STATE: SE = State Endangered; ST State Threatened; SR = State Rare; SSC = State Species of Special Concern; SX = State Extirpated; SG = State Significant; WL = Watch List
GRANK: Global Heritage Rank: G1 = Critically Imperiled Globally; G2 = Imperiled Globally; G3 = Rare or Uncommon Globally; G4 = Widespread and abundant globally but with long term concerns; G5 = Widespread and abundant globally; G? = unranked; GX = Extinct; Q = Uncertain Rank; T = Taxonomic Subunit Rank
SRANK: State Heritage Rank: S1 = Critically Imperiled in State; S2 Imperiled in State; S3 = Rare or Uncommon in State; S4 = Widespread and abundant in state but with long term concern; SG = State Significant; SH = Historical in State; SX = State Extirpated; B = Breeding Status; S? = Unranked; SNR = Unranked; SNA = Nonbreeding Status Unranked

It is important to note the following species have been identified within the watershed and deserve special attention. These species were taken into consideration when designating critical areas in which to concentrate our efforts.

The Greater Redhorse (*Moxostoma valenciennesi*) and the Eastern Sand Darter (*Ammocrypta pellucid*) have both been identified in the Middle Eel River Watershed. The presence of the Greater Redhorse in the Eel River is unique as this is the only known location within the entire Ohio River Drainage Basin (Simon, 2006). An Eastern Sand darter was located in the mainstem of the Middle Eel River close to North Manchester in 2007, and in 2009 was found in Squirrel Creek and the mainstem of the Eel River.

Several shells of two federally endangered mussels were found in the watershed within the mainstem of the Middle Eel River in 2008, however, they were weather dead, which means the shells did not contain a living organism and the shells were separated from each other. The two mussels were the Northern Riffleshell (*Epioblasma torulosa rangiana*), and Clubshell (*Pleurobema clava*). One state endangered mussel, Rabbitsfoot (*Quadrula cylindrical cylindrical*) was found living in the mainstem of the Middle Eel River, and was documented in 2009 as far north as Chili, IN.

River otters (*Lutra canadensis*), a species of special concern, were reintroduced into the Eel River from 1995-1999 with much success.

The range of the Indiana bat (*Myotis sodalis*), a federally endangered species, is within the watershed.

Even though there are several plants of concern that may exist within the watershed, a plant survey for the watershed has not been completed and is not part of this project.

The Tippecanoe Audubon Society is in the process of compiling a breeding bird survey listing the presence/absence of nesting birds within the Watershed, see Appendix H.

2.11 Incorporated Cities

There are only three incorporated cities completely within the Middle Eel River Watershed; Silver Lake, Roann and Denver, with two additional cities partially within the watershed; North Manchester and Mexico (Figure 43). Demographics for each city are listed below.

2.11.1 Silver Lake

Total land area 0.3 square miles, elevation 899 feet, located in Kosciusko County. As of the census of 2000, there were 546 people, 207 households, and 156 families residing in the town. The population density was 1,874.9 people per square mile (726.9/km^2). There were 221 housing units at an average density of 758.9/sq mi (294.2/km^2). The racial makeup of the town was 95.79% White, 0.37% Native American, 0.18% Asian, 2.75% from other races, and 0.92% from two or more races. Hispanic or Latino of any race were 3.48% of the population.

There were 207 households out of which 35.7% had children under the age of 18 living with them, 59.9% were married couples living together, 9.7% had a female householder with no husband present, and 24.6% were non-families. 18.8% of all households were made up of individuals and 8.2% had someone living alone who was 65 years of age or older. The average household size was 2.64 and the average family size was 2.97. In the town the age of the population varied out with 27.3% under the age of 18, 6.6% from 18 to 24, 29.3% from 25 to 44, 22.9% from 45 to 64, and 13.9% who were 65 years of age or older. The median age was 36 years. For every 100 females there were 88.3 males. For every 100 females age 18 and over, there were 90.9 males.

The median income for a household in the town was $33,088, and the median income for a family was $36,875. Males had a median income of $31,442 versus $21,000 for females. The per capita income for the town was $13,561. About 9.4% of families and 12.1% of the population were below the poverty line, including 14.5% of those under age 18 and 10.2% of those age 65 or over.

Silver Lake has a wastewater treatment facility that discharges only 2 to 3 times per year. They do not treat for phosphorus before discharge.

2.11.2 Roann

Total land area 0.2 square miles, elevation 755 feet, located in Wabash County. As of the census of 2000, there were 400 people, 153 households, and 117 families residing in the town. The population density was 2,226.4 people per square mile (858.0/km^2). There were 164 housing units at an average density of 912.8/sq mi (351.8/km^2). The racial makeup of the town was 98.00% White, 0.25% from other races, and 1.75% from two or more races. Hispanic or Latino of any race were 0.25% of the population.

There were 154 households out of which 36.6% had children under the age of 18 living with them, 61.4% were married couples living together, 8.5% had a female householder with no husband present, and 22.9% were non-families. 21.6% of all households were made up of individuals and 11.1% had someone living alone who was 65 years of age or older. The average household size was 2.61 and the average family size was 2.99. In the town the age of the population was spread out with 27.5% under the age of 18, 9.0% from 18 to 24, 26.0% from 25 to 44, 25.0% from 45 to 64, and 12.5% who were 65 years of age or older. The median age was 35 years. For every 100 females there were 91.4 males. For every 100 females age 18 and over, there were 94.6 males.

The median income for a household in the town was $41,000, and the median income for a family was $42,955. Males had a median income of $29,833 versus $22,411 for females. The per capita income for the town was $20,880. About 4.8% of families and 9.5% of the population were below the poverty line, including 12.7% of those under age 18 and 9.1% of those age 65 or over.

Roann has a wastewater treatment facility that does not treat for phosphorus before discharging.

2.11.3 Denver

Total land area 0.2 square miles, elevation 712 feet, located in Miami County.
As of the census of 2000, there were 541 people, 189 households, and 158 families residing in the town. The population density was 2,318.0 people per square mile (908.2/km²). There were 200 housing units at an average density of 856.9/sq mi (335.7/km²). The racial makeup of the town was 98.89% White, 0.55% Native American, and 0.55% from two or more races. Hispanic or Latino of any race were 0.37% of the population.

There were 189 households out of which 48.7% had children under the age of 18 living with them, 64.0% were married couples living together, 16.9% had a female householder with no husband present, and 15.9% were non-families. 13.8% of all households were made up of individuals and 6.3% had someone living alone who was 65 years of age or older. The average household size was 2.86 and the average family size was 3.11. In the town the age of the population was spread out with 30.9% under the age of 18, 6.8% from 18 to 24, 34.2% from 25 to 44, 18.5% from 45 to 64, and 9.6% who were 65 years of age or older. The median age was 33 years. For every 100 females there were 104.2 males. For every 100 females age 18 and over, there were 88.9 males.

The median income for a household in the town was $36,250, and the median income for a family was $36,985. Males had a median income of $29,286 versus $21,250 for females. The per capita income for the town was $15,224. About 5.0% of families and 9.5% of the population were below the poverty line, including 14.8% of those under age 18 and 4.9% of those age 65 or over.

Denver has a wastewater treatment plant and a separate storm drain system. The presence of a separate storm drain eliminates any raw sewage discharge into the river during heavy rain events. They do not treat for phosphorus prior to discharge.

2.11.4 North Manchester

Total land area within the watershed is .04 square miles, elevation 771 feet, located in Wabash County. As of the census of 2000, there were 6,260 people, 2,192 households, and 1,374 families residing in the town. The population density was 1,735.5 people per square mile (669.5/km²). There were 2,327 housing units at an average density of 645.1/sq mi (248.9/km²). The racial makeup of the town was 96.15% White, 0.93% African American, 0.27% Native American, 0.83 Asian, 0.06 Pacific Islander, and 0.96% from two or more races. Hispanic or Latino of any race were 1.74% of the population.

There were 2,192 households out of which 26.0% had children under the age of 18 living with them, 51.0% were married couples living together, 8.9% had a female householder with no husband present, and 37.3% were non-families. 31.1% of all households were made up of individuals and 13.9% had someone living alone who was 65 years of age or older. The average household size was 2.29 and the average family size was 2.85. In the town the age of the population was spread out with 17.8% under the age of 18, 21.9% from 18 to 24, 20.1% from 25 to 44, 17.9% from 45 to 64, and 22.3% who were 65 years of age or older. The median age was 36 years. For every 100 females there were 81.4 males. For every 100 females age 18 and over, there were 78.2 males.

The median income for a household in the town was $35,448, and the median income for a family was $46,781. Males had a median income of $31,795 versus $23,388 for females. The per capita income for the town was $17,140. About 4.8% of families and 8.7% of the population were below the poverty line, including 6.9% of those under age 18 and 5.0% of those age 65 or over. North Manchester has a wastewater treatment plant that is in the process of separating its sewage from its stormwater. In 2009 there were 40 episodes of discharge of raw sewage to the Eel River from North Manchester. The North Manchester wastewater treatment plant does not treat for the removal of phosphorus and may be contributing to high phosphorus and *E. coli* counts in the mainstem of the Eel River.

2.11.5 Mexico, IN

Total land area within the watershed is 2.19 square miles, elevation 984 feet, located in Miami County. As of the census of 2000, there were 984 people, 402 households, and 297 families residing in the town. The population density was 179.6 people per square mile (69.3/km²). There were 416 housing units at an average density of 75.9/sq mi (29.3/km²). The racial makeup of the town was 98.27% White, 0.30% African American, 0.71% Native American, 0.10 Pacific Islander, and 0.61% from two or more races. Hispanic or Latino of any race were 0.51% of the population.

There were 402 households out of which 29.4% had children under the age of 18 living with them, 62.7% were married couples living together, 8.5% had a female householder with no husband present, and 26.1% were non-families. 22.1% of all households were made up of individuals and 8.7% had someone living alone who was 65 years of age or older. The average household size was 2.45 and the average family size was 2.86. In the town the age of the population was spread out with 21.1% under the age of 18, 8.5% from 18 to 24, 27.0% from 25 to 44, 28.4% from 45 to 64, and 14.9% who were 65 years of age or older. The median age was 42 years. For every 100 females there were 102.9 males. For every 100 females age 18 and over, there were 97.5 males.

The median income for a household in the town was $49,234, and the median income for a family was $55,776. Males had a median income of $37,778 versus $26,389 for females. The per capita income for the town was $19,150. About 2.9% of families and 5.1% of the population were below the poverty line, including none of those under age or 65 or over. Mexico is in the process of installing a wastewater treatment plant, however as of this writing waste is still handled with all septic systems.

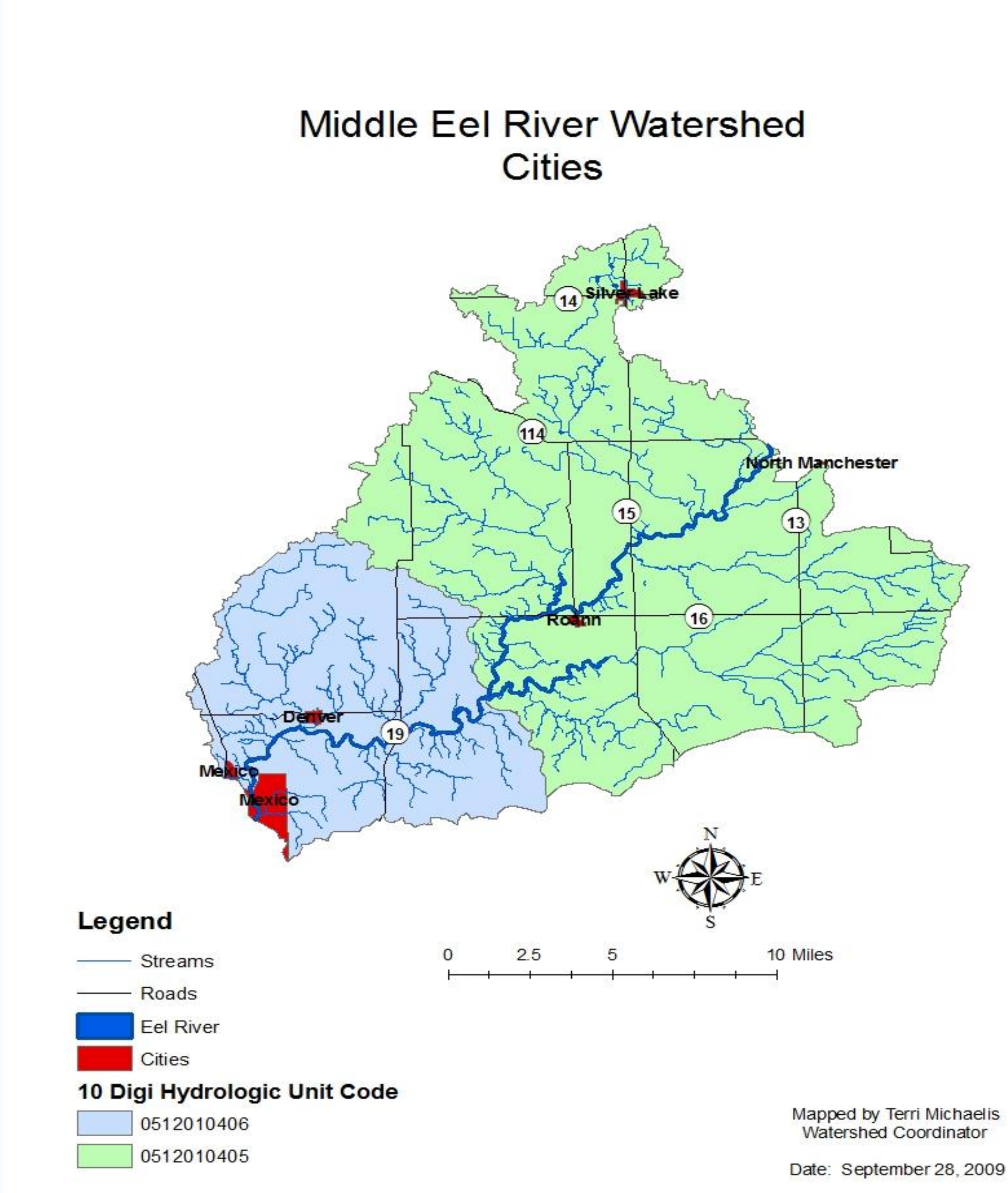

Figure 2-43. Middle Eel River Watershed, Incorporated Cities (Indiana Geological Survey 2001).

2.12 NPDES Permits

IDEM administers the National Pollution Discharge Elimination System (NPDES) permit program required by the Clean Water Act (CWA). IDEM addresses activities that cause or may cause discharge of pollutants into the waters of the State. According to IDEM, the purpose of NPDES permits is to control point source pollution of the state's waters. The NPDES permit requirements must ensure that, at a minimum, any new or existing point source discharger must comply with technology-based treatment requirements that are contained in 327 IAC 5-5-2. According to 327 IAC 5-2-2, "Any discharge of pollutants into waters of the State as a point source discharge, except for exclusions made in 327 IAC 5-2-4, is prohibited unless in conformity with a valid NPDES permit obtained prior to discharge." This is the most basic principal of the NPDES permit program. (IDEM Office of Water Quality, 2009). There are nine NPDES permits for wastewater facilities in the watershed, Figure 2-44, please note there are two NPDES Permits issued for Denver, IN. Confined Animal Feeding Operations also require NPDES permits and are addressed in the next section.

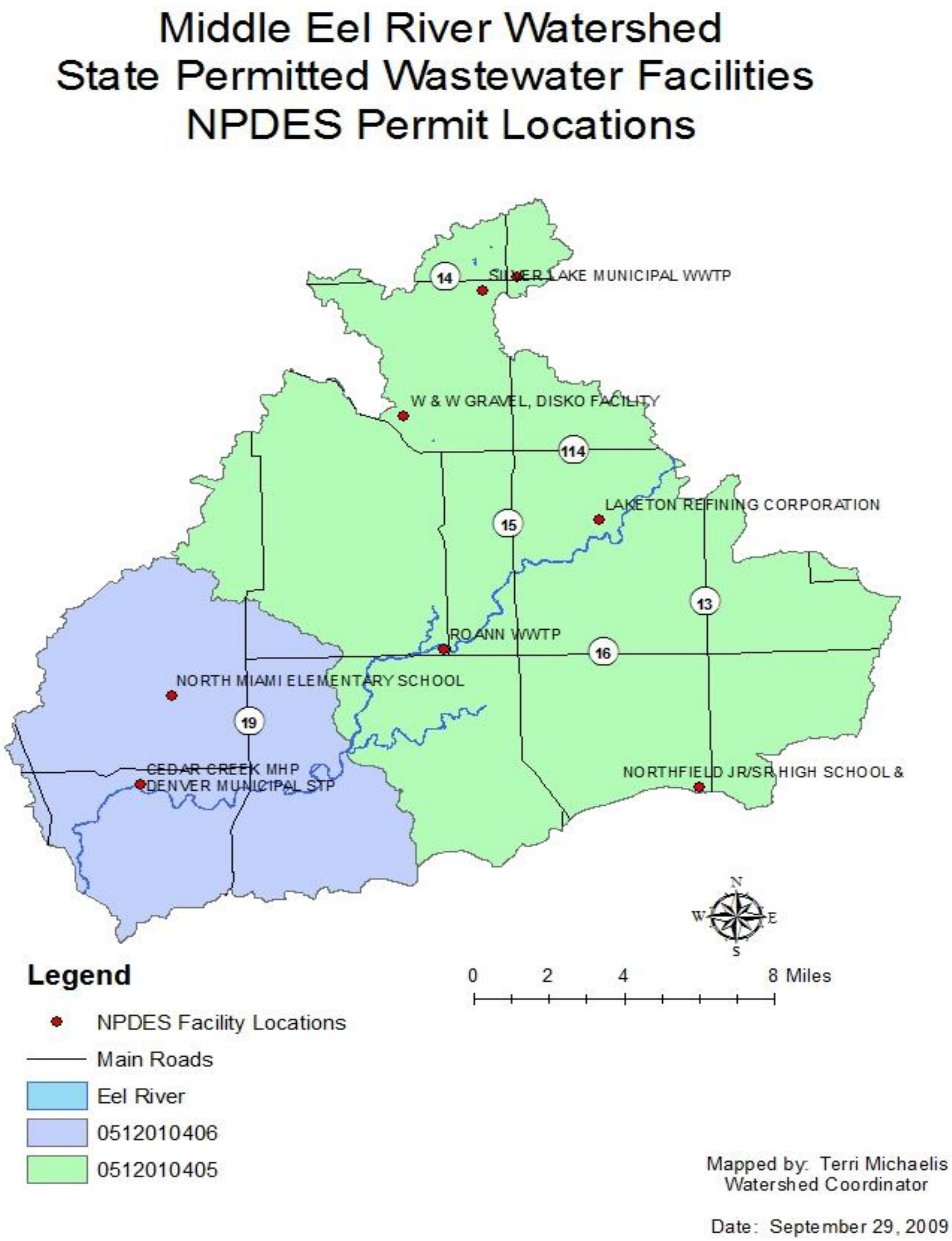

Figure 2-44. Middle Eel River Watershed Wastewater Facilities - National Pollutant Discharge Elimination System Permits (NPDES), 2002. (IDEM - Office of Water Quality, 2009). Note there are two NPDES permits at Cedar Creek MHP and Denver Municipal Sewage Treatment Plant.

2.13 Animal Feeding Operations

There are 11 large, 48 medium and 12 small Confined Feeding Operations (CFO) in the watershed and 19 large, 1 medium and 1 small Concentrated Animal Feeding Operations (CAFO). There are different regulations and guidelines for CFOs and CAFOs which are defined below. The total numbers and types of animals being housed in a CFO and/or CAFO in the watershed as of 9/30/09 (Dunn, 2009) are listed below:

- Hogs - 189,709
- Beef Cattle - 1,598
- Dairy Cattle - 1,590
- Veal - 11,330
- Chickens - 5,191,296
- Ducks - 24,700
- Sheep - 10

2.13.1 Confined Feeding Operations (CFOs)

Confined feeding is the raising of animals in any confined area for at least 45 days during any year where there is no ground cover or vegetation over half of the confined area. CFOs are defined by Indiana law as any feeding operation engaged in the confined feeding of at least:

- 300 cattle or
- 600 swine or
- 600 sheep or
- 30,000 fowl (chickens, turkey or other poultry)

IDEM regulates the CFOs through the Office of Land Quality which is responsible for permitting, compliance monitoring and enforcement activities as outlined in the Confined Feeding Control Law. The following criteria must be met in order to be a permitted CFO:

- Must have at least 180 days storage for manure and wastewater
- Be designed according to the design standards outlined in the CFO Guidance Manual
- Have sufficient acreage available for application of manure generated
- Provide adequate seperation distances of the manure storage structures and confinement lots from roads, wells, and surface waters
- Include a manure management plan detailing soil testing, manure testing and manure application areas
- Provide record keeping at the CFO which includes:
    - Manure type
    - Amount of manure generated
    - Amount of manure applied to land
    - Manure storage methods

- Type of application equipment used
- Application rates based on laboratory analysis

2.13.2 Confined Animal Feed Operations (CAFOs)

The CAFO permit process and operational requirements are slightly different than for CFOs. CAFOs in Indiana are required to obtain an NPDES permit through IDEM according to the USEPA Clean Water Act regulations for CAFOs finalized in 2003. CAFOs are considered to be point sources for pollution by the USEPA. IDEM developed a general permit for CAFOs (327 IAC 15-15) effective in February 2004. Two types of NPDES permits are available for CAFOs:

1. The general permit establishes uniform criteria to be followed by those with a general permit.

2. An individual permit provides an opportunity for IDEM to require additional protective measures, or for the farm to construct or operate in a manner different than that prescribed by the general permit regulation.

All of the 21 CAFOs within the Middle Eel River Watershed have general permits.

The main determining factor for requirement of an NPDES permit is the number and species of animals. The threshold for each species is shown in Table 2-10.

Table 2-10. Threshold number and species that require CAFO NPDES permit.

Threshold Number Requiring NPDES Permit	Species
700	Mature Dairy Cows
1,000	Veal Calves
1,000	Cattle - other than mature dairy cows
2,500	Swine - above 55 pounds
10,000	Swine - less than 55 pounds
500	Horses
10,000	Sheeps or Lambs
55,000	Turkeys
30,000	Laying Hens/Broilers with liquid manure handling system
125,000	Broilers with solid manure handling system
82,000	Laying Hens with solid manure handling system
30,000	Ducks with solid manure handling system
5,000	Ducks with a liquid manure handling system

Any CAFO seeking an NPDES permit must provide to IDEM the following information:

- A completed NPDES permit application form;
- A completed CFO approval application form;
- Confirmation that any necessary public notice requirements were conducted ;
- Plans and specifications for the design and construction of the animal confinement structure and manure treatment and control facilities;
- At least two soil borings within the area of any liquid waste storage structures;
- A manure management plan outlining procedures for soil testing and manure testing;
- Soil Survey and Topographic Maps of manure application areas which outline field borders, identify the owner, and acres available;
- Farmstead plan showing the location of the buildings and waste storage structures in relation to the following features within 500 feet:
    - water wells
    - drainage patterns
    - property lines
    - roads
    - streams, ditches and tile inlets

The following conditions must be satisfied for IDEM to issue an NPDES permit:

- The submitted application forms must be complete with no missing applicable information;
- Confirmation that public notice requirements were satisfied;
- Provides at least 6 months of manure and wastewater storage capacity;
- Has sufficient acreage available for application of the manure and wastewater;
- Provides adequate separation distances of the manure storage structures and confinement lots from property lines, roads, wells, and surface waters;
- If a construction application is submitted that the structures are designed to be built according to the design standards outlined in the CFO rule and CFO Guidance Manual.

There are 17 large CAFOs, 1 medium CAFO and 1 small CAFO within the watershed. Figures 2-45 through 2-47 show the total number and type of animals in CAFOs within the watershed. Figure 2-48 shows the percentage of each type of animal in CAFOs within the watershed. Figures 2-49 through 2-52 show the total number and type of animals in CFOs within the watershed. Figure 2-53 shows the percentage of each type of animal in CFOs within the watershed, and Figure 2-54 shows the locations of CAFOs and CFOs within the Middle Eel River Watershed.

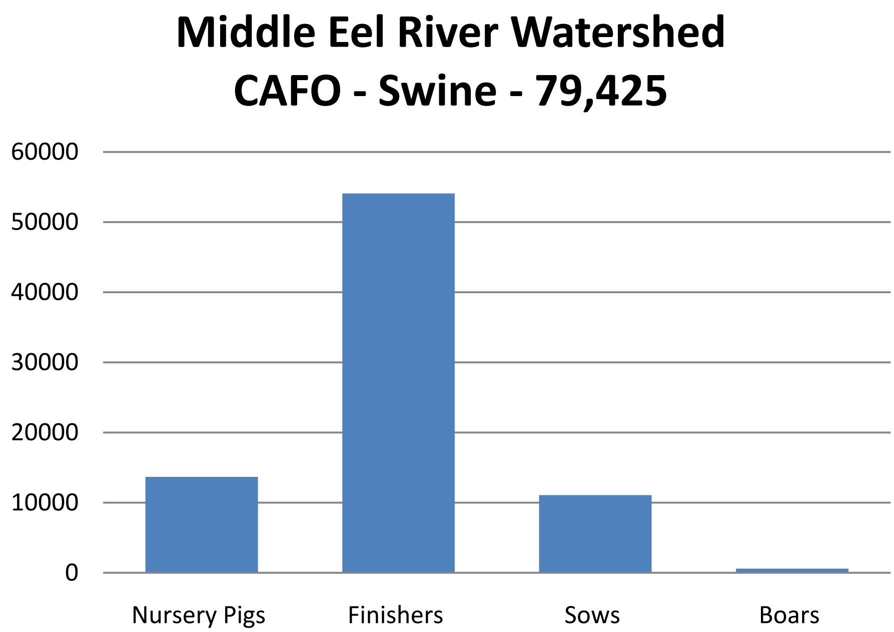

Figure 2-45. Middle Eel River Watershed - Number of swine in CAFOs within the watershed (Dunn, 2009).

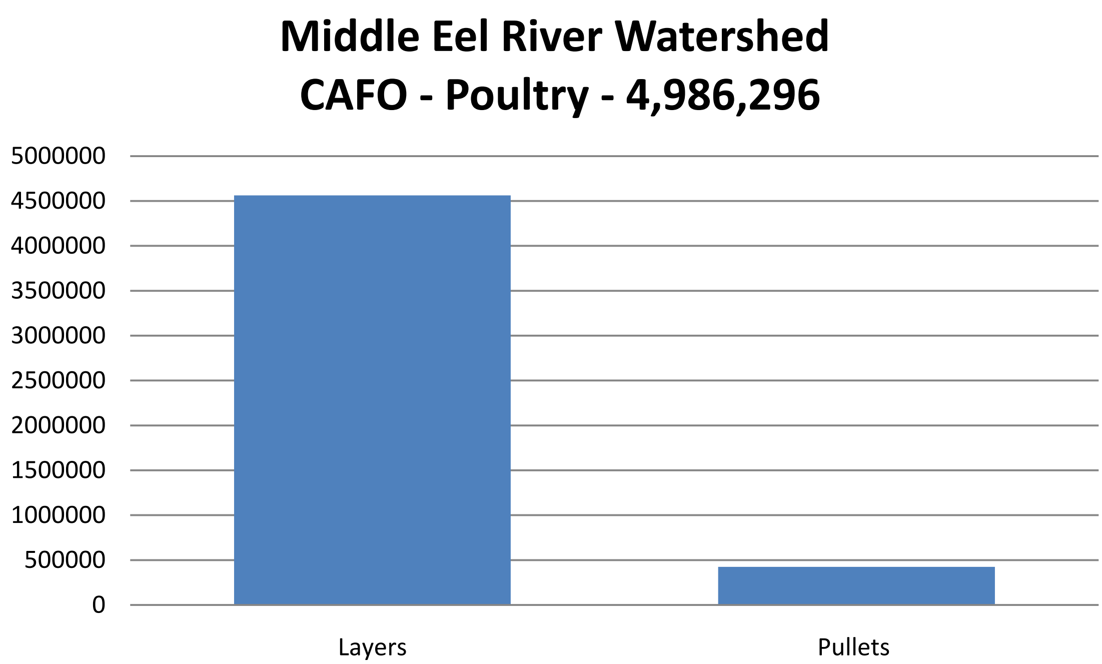

Figure 2-46. Middle Eel River Watershed - Number of chickens in CAFOs within the watershed (Dunn, 2009).

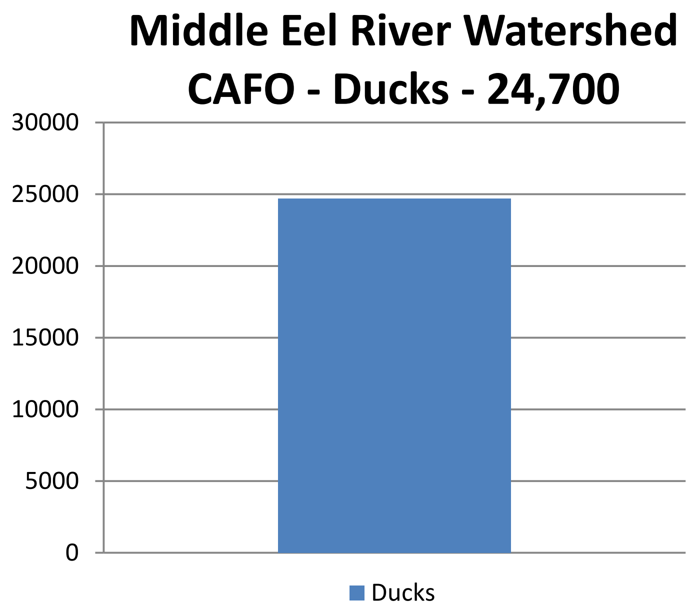

Figure 2-47. Middle Eel River Watershed - Number of ducks in CAFOs within the watershed (Dunn, 2009).

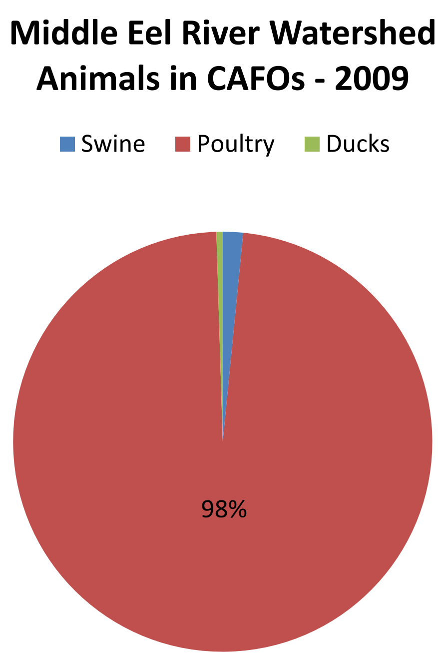

Figure 2-48. Middle Eel River Watershed, percentage of animal type in CAFOs within the watershed.

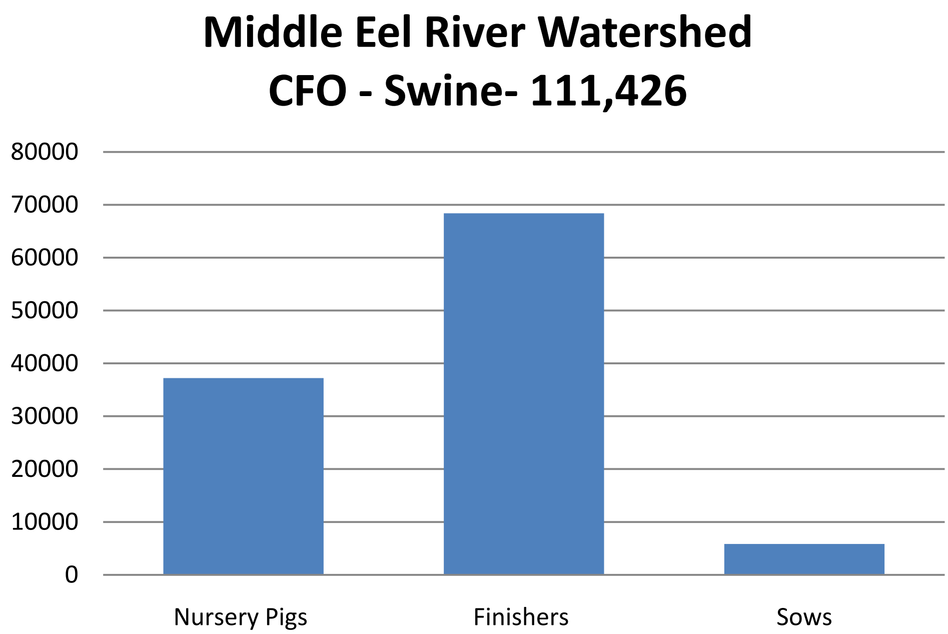

Figure 2-49. Middle Eel River Watershed - Number of hogs in CFOs within the watershed (Dunn, 2009).

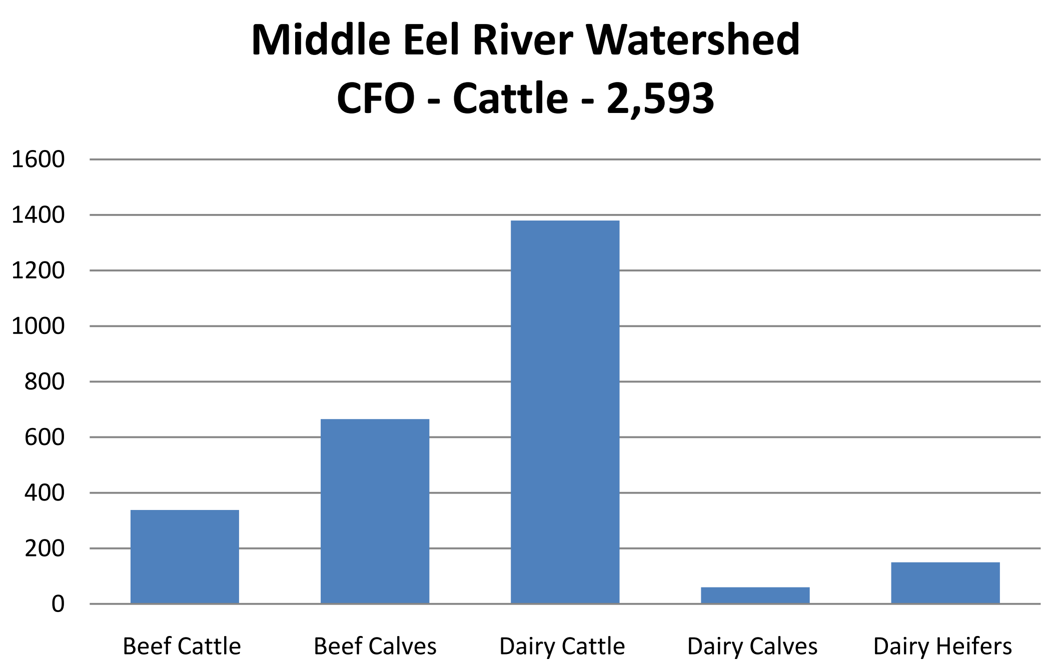

Figure 2-50. Middle Eel River Watershed - Number of cattle in CFOs within the watershed (Dunn, 2009).

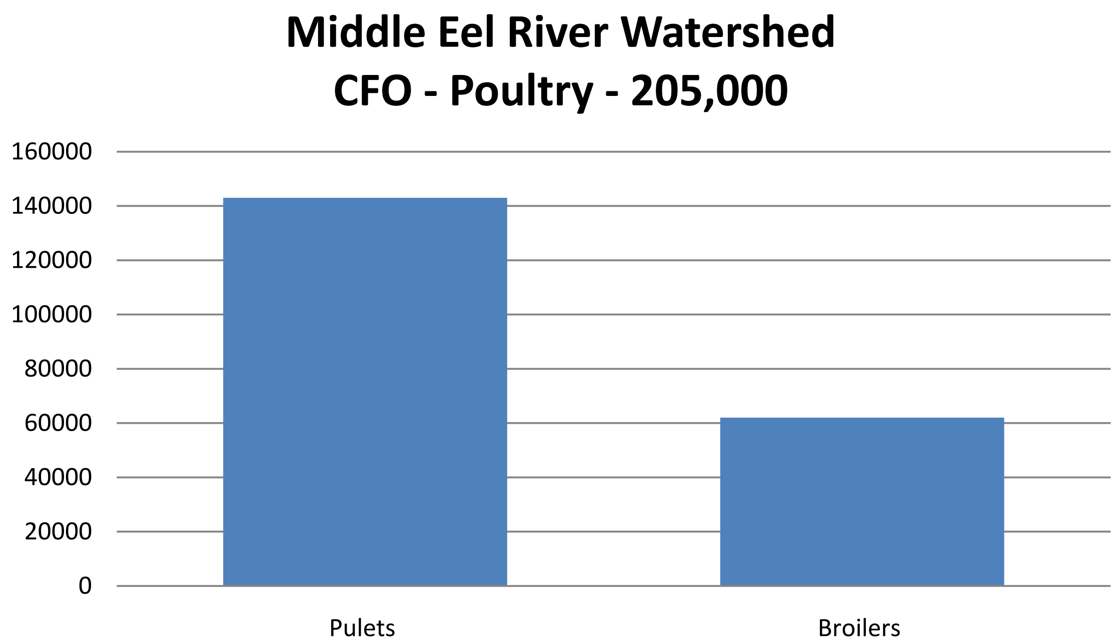

Figure 2-51. Middle Eel River Watershed - Number of chickens in CFOs within the watershed (Dunn, 2009).

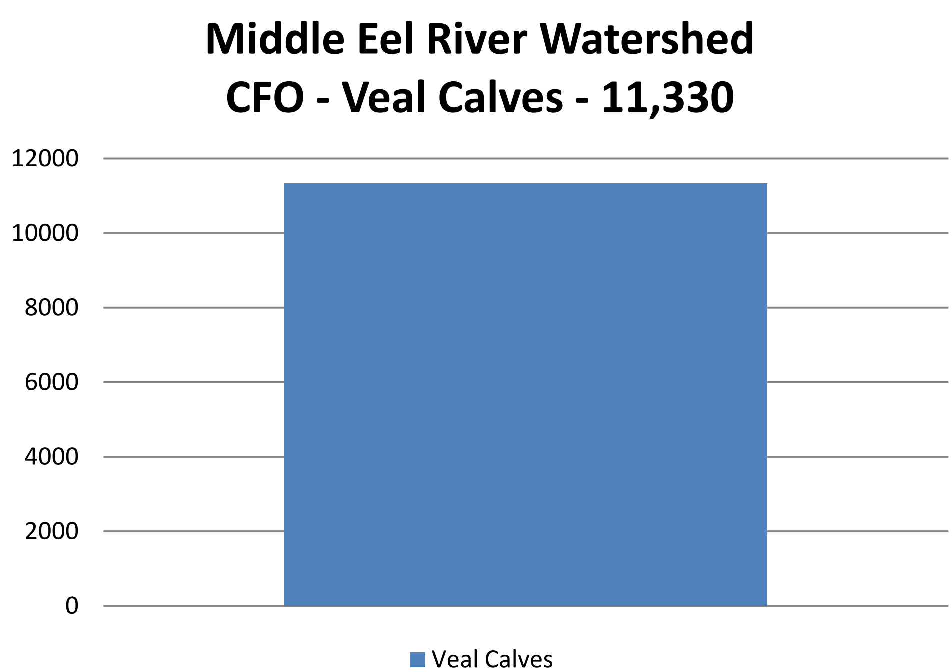

Figure 2-52. Middle Eel River Watershed - Number of veal calves in CFOs within the watershed (Dunn, 2009).

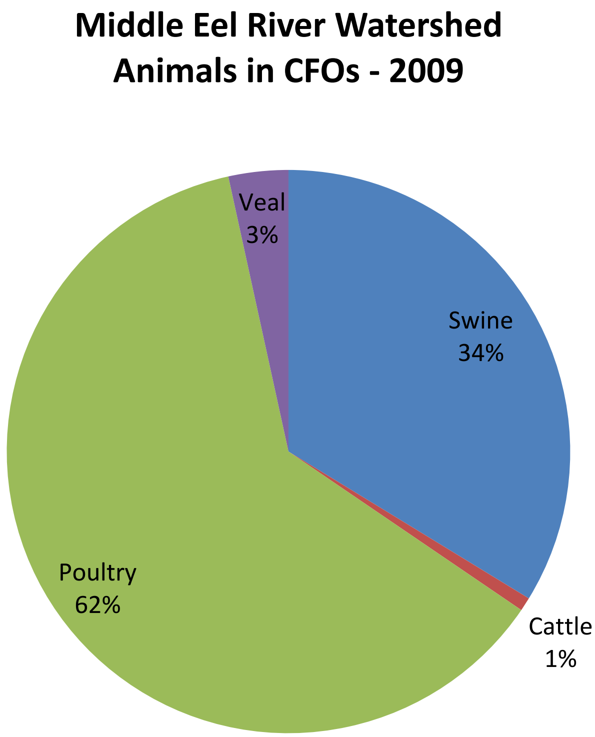

Figure 2-53. Middle Eel River Watershed, percentage of animal type in CFOs within the watershed.

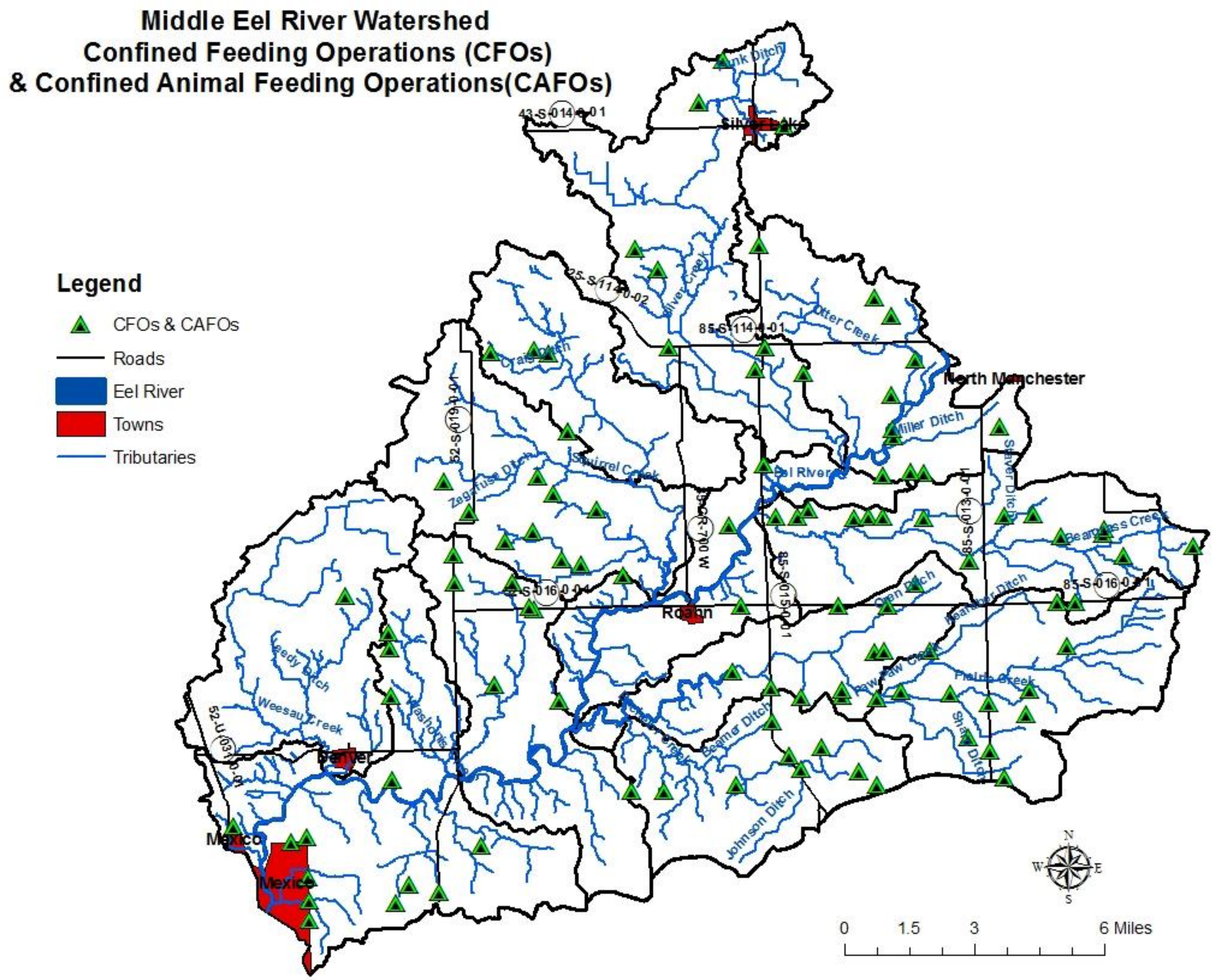

Figure 2-54. Middle Eel River Watershed, location of CFOs & CAFOs

2.14 Combined Sewer Overflow(CSO) & Septic Systems

The city of North Manchester is in the process of transitioning from a combined sewer overflow system to separated storm drains. In a combined sewer overflow system, storm water and sewage waste use the same pipes. Consequently when a heavy rain occurs, the water draining off the land and the sewage combine together and exceed the capacity of the drainage pipe. In order to maintain sewage service to the city, valves are opened that allow discharge of untreated sewage to the Eel River. This may cause an increase in nutrients, particularly phosphorus and nitrogen as well as an increase in E. coli concentrations, however this is a point source and is beyond the scope of this watershed management plan.

Using the EPA STEPL Model for the Eel River Watershed, it is estimated that there are 1,526 septic systems within the watershed. The estimated rate of failure for septic systems in the Middle Eel River Watershed using the EPA STEPL Model is 1.09%. It is therefore estimated that 17 septic systems within the Watershed are failing.

2.15 Agricultural Tile Drainage

Tile drainage in Indiana is intimately tied to row crop agriculture. No agency tracts the placement or number of tile drains in Indiana fields or watersheds. Subsurface tile drains are common across the watershed and can be found by the discharge pipes seen in ditches and streams. It is well known that nitrate binds and moves with water. As water drains off the land through the tile drains it may carry excess nitrogen from the fields and cause an increase in the nitrogen concentrations in rivers and streams.